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NOVEMBER 2005
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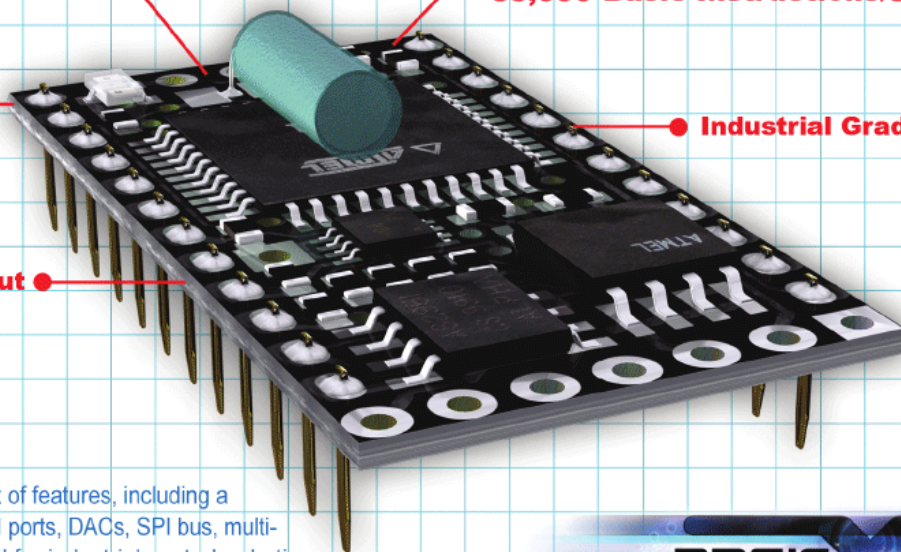
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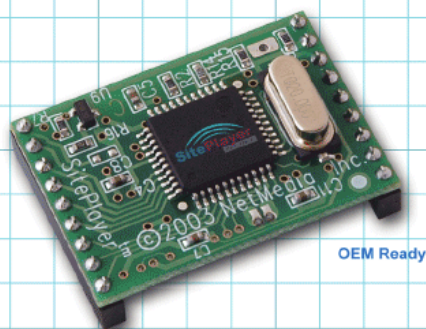
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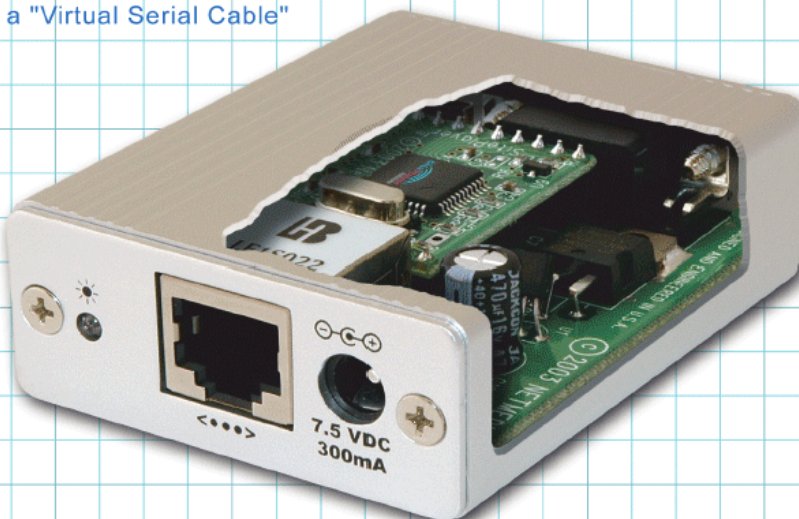
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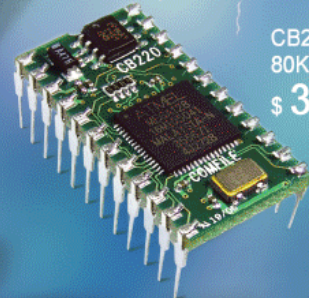
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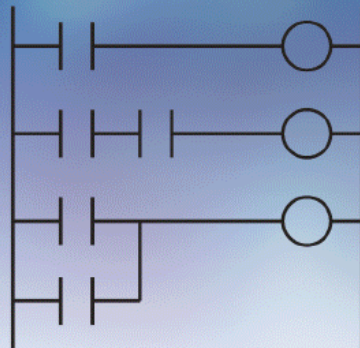
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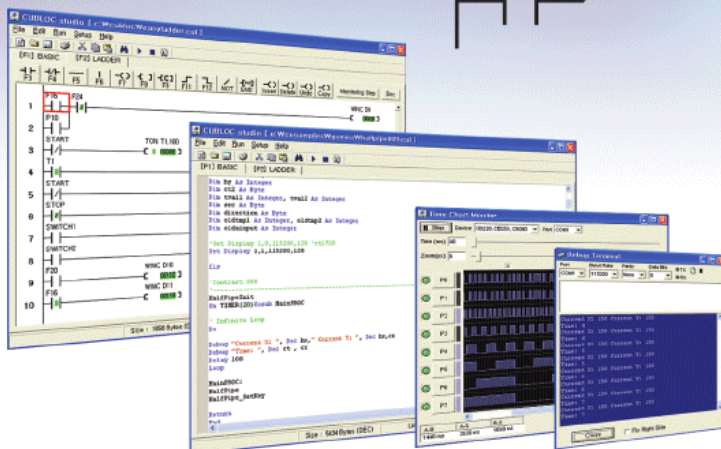


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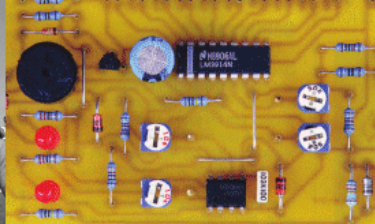
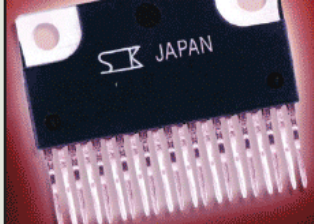
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NUTS AND VOLTS

NOVEMBER 2005

PROJECTS and FEATURES

- 38 BUILD AN MP3 PLAYER PLATFORM — Part 2**
This month, the actual construction, testing, operation, and possible modifications are covered.
■ *By Robert Armstrong*

- 44 SMALL DC MOTOR PWM SPEED CONTROLLER**
The DC motor speed controller described in this article uses a modified form of PWM, a technique for which you will find numerous applications such as R/C cars and robots.
■ *By Bill Donofrio*

- 48 SORT YOUR ELECTRONIC COMPONENTS BY VOICE**
Create a resistor color code calculator using XHTML + Voice.
■ *By Marc White*

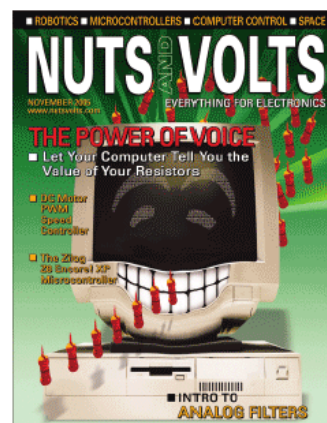
- 56 INTRODUCTION TO FILTERS**
Active and passive analog filters built with discrete components are the focus of this tutorial.
■ *By Russell Kincaid*

- 60 DATA PROCESSING USING SCAM — Part 2**
Learn how Content-Addressable Memory processes queries against simple and complex data types.
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- 64 REVIEW: Performance Electronics for Cars**
This book has 160 pages dedicated to DIY hacks for myriad automotive systems.
■ *By James Antonakos*

ON THE COVER ...

Check out Marc White's project on Page 48 that enables your computer to tell you what the value of your resistors are.



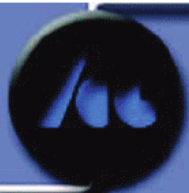
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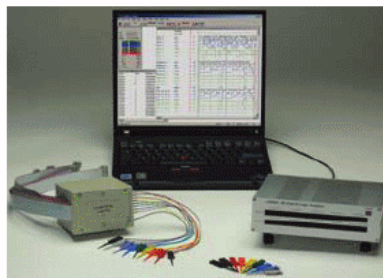
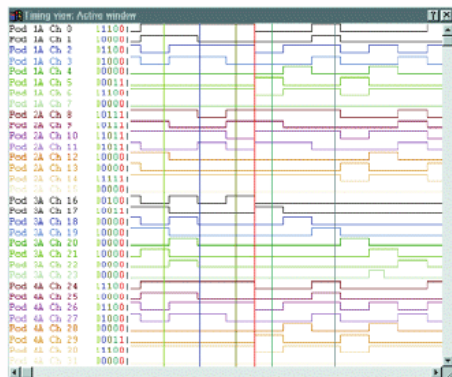


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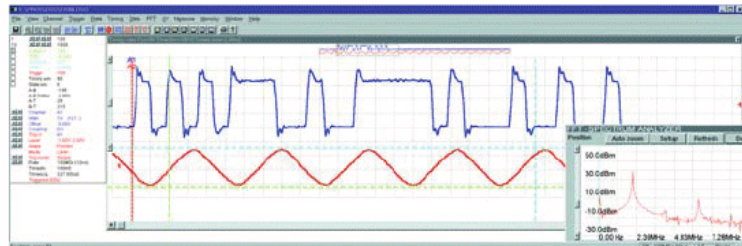
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READER FEEDBACK

NUTS AND VOLTS

EVERYTHING FOR ELECTRONICS

>> MOORE COWBELL

I like your magazine and look forward to it every month, however, it needs something ... "More cowbell." Would it be possible to add more pages and columns to your magazine? I often find it to be a quick read and a long wait for the next issue. I don't want to speak for everyone but I personally wouldn't mind if these new pages were ad-supported (if that's how it works). Keep up the good work.

Mike James, Sr.
St. Louis, MO

>> WRONG PICK ON PIC

The August 2005 article "What the L is it?" is a great article!

The sidebar "Picking a PIC" was a waste of space and a disservice to PIC

newbies. Microchip makes a 16F54 Flash part that's a drop-in replacement for the 16C54. There are documents on their website showing the migration steps from 16C5x devices to the newer 16F5x parts.

Chuck Craft

>> MISWIRE 'RELAYED'

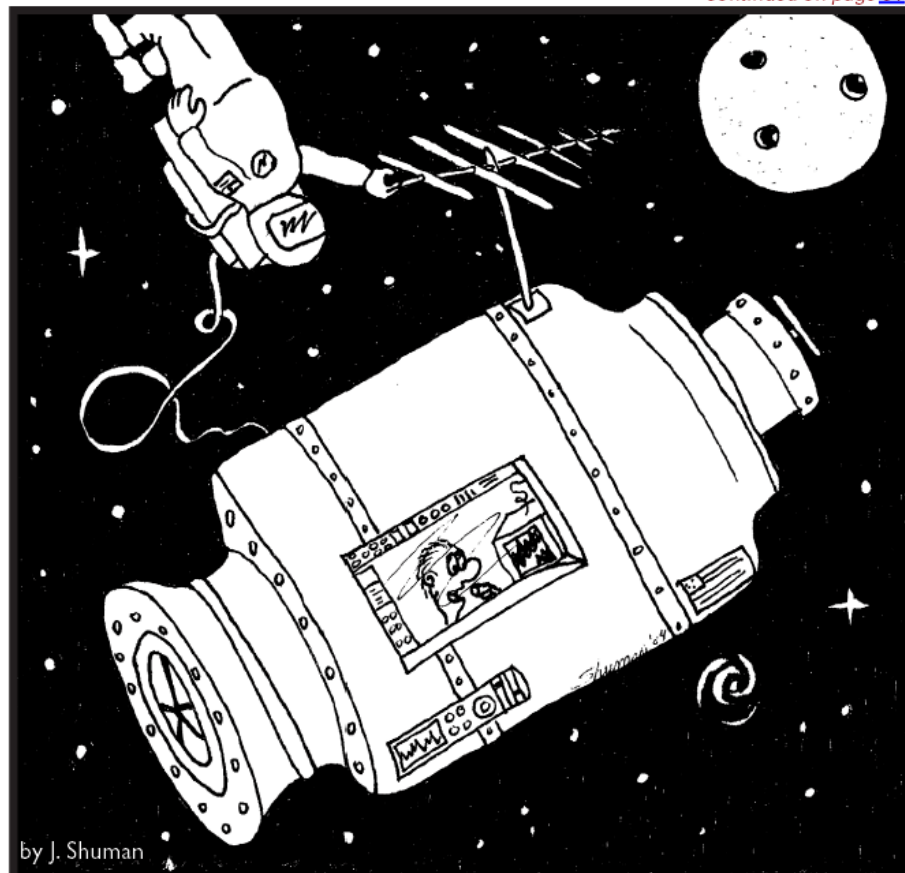
In the September *Nuts & Volts*, on page 34, schematic 4, the relay_dpst cannot work the way it is wired. One pin of the relay should be tied to the +V and the other pin on the transistor collector. The remaining is okay.

Mike Laganieri

Mike is correct. I will post the changes on my website at www.kronosrobotics.com My thanks to Mike for catching this and my apologies for any inconveniences.

Michael Simpson
Writer

Continued on page 31



by J. Shuman

A little more...more...There! There s Seinfeld!
Ohp! We lost it...a little more...more

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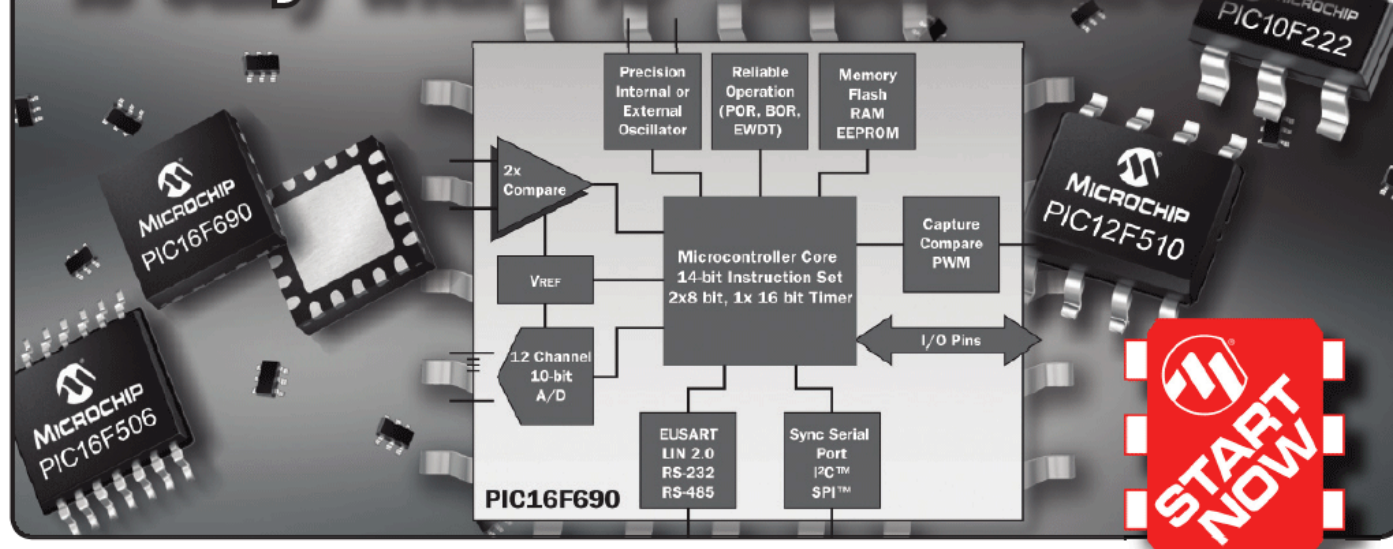
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Shannon Lemieux
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Peripheral-Rich Mid-Range PIC Microcontroller	PIC12F	14-bit	8	1792 to 2048	32 kHz to 8 MHz	10-bit	●	●	●	●
	PIC16F	14-bit	14 to 64	1792 to 14336	32 kHz to 8 MHz	10-bit	●	●	●	●

* Easily migratable to Mid-Range PIC Microcontroller Architecture; † Microchip's proprietary low power technology.

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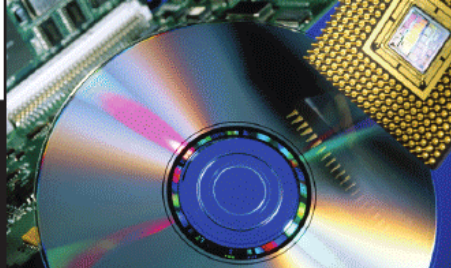


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>>>> ADVANCED TECHNOLOGIES

NEW CLUE TO ORIGIN OF UNIVERSE

If you spend a lot of time thinking about how the Big Bang functioned, you will be glad to know that scientists at MIT's Haystack Observatory have taken a step toward explaining it. It was recently reported that a team led by Haystack researcher Alan E. E. Rogers has accomplished the first radio detection of deuterium, an atom that plays a key role in the theory. The amount

of deuterium can be related to the amount of dark matter in the universe, so its detection is of interest. Because of the way deuterium was created in the Big Bang, an accurate method of measuring deuterium would allow scientists to set constraints on models of the Big Bang. It also would be an indicator of the density of cosmic baryons, which would indicate whether ordinary matter is dark and found in regions such as black holes, gas clouds, or brown dwarfs, or is luminous and can be found

in stars. However, accurate measurements have been difficult with Earth-based instruments. It seems that there is only

■ STATION WITH ACTIVE CROSSED DIPOLES WITH DIRECTORS. RFI MONITORING FACILITY IN BACKGROUND.

about one deuterium atom per every 100,000 hydrogen atoms in space, and at optical wavelengths the two can be easily confused. However, at radio wavelengths, more accurate and consistent measurements can be made, so the new method may lead to a greater understanding of where everything came from.

The Deuterium Array at Haystack is a soccer field sized installation consisting of 25 5 x 5 crossed dipole stations, conceived and built at the Haystack facility with support from the National Science Foundation, MIT, and TruePosition, Inc. For a detailed description of the project, visit web.haystack.mit.edu/deuterium/deuterium.html



PHOTO COURTESY OF HAYSTACK OBSERVATORY, MIT.

■ NIST RESEARCHERS TRAPPED ALUMINUM AND BERYLLIUM IONS IN THE ABOVE DEVICE IN EXPERIMENTS DESIGNED TO PRODUCE AN ATOMIC CLOCK THAT COULD BE SIGNIFICANTLY MORE PRECISE THAN THOSE CONSIDERED MOST ACCURATE TODAY.

TANDEM IONS MAY IMPROVE ATOMIC CLOCK ACCURACY

Today's international time and frequency standards measure naturally occurring oscillations of cesium atoms that fall within the microwave frequency range — about 9 billion Hz. You might think that would provide enough precision, but physicists at the National Institute of Standards and Technology (NIST, www.nist.gov) have developed a technique that could divide time into as many as 100,000 times more units, or about 1 quadrillion Hz. Basically, they use natural oscillations of two different types of ions, confined in a single trap, to produce "ticks." This tandem tech-

nique involves the use of a single beryllium ion to sense the higher-frequency vibrations of an aluminum ion. The NIST group used ultraviolet lasers to transfer energy from the aluminum's vibrations to a shared "rocking" motion of the pair of ions, and then detected the magnitude of the vibrations through the beryllium ion. This technique solves a long-standing problem of how to monitor the properties of an aluminum ion, which cannot be manipulated easily using standard laser techniques. Not only may this technique lead to more accurate atomic clocks, it could result in simplified designs for quantum computers. More information about NIST research in this field is available at <http://qubit.nist.gov>

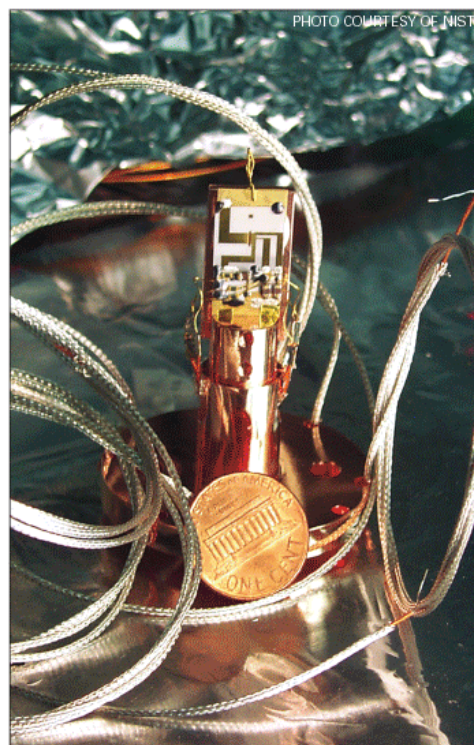


PHOTO COURTESY OF NIST

>>>> COMPUTERS & NETWORKING

SMART MOUSE INTRODUCED

Yes, we're getting sick of "smart" devices. Cell phones that calculate your gas mileage, talking can openers, car ignitions that won't operate unless you remembered to brush your teeth — all sorts of superfluous and annoying gadgets are invading our lives on a daily basis. Even so, you might want to consider the new MX610 laser mouse from Logitech (www.logitech.com). Using 2.4 GHz cordless technology, it sports an on-board microprocessor that allows it not only to send data to the computer, but also to receive information from it. As a result, it can let you know when you have received an email or instant message (blue light for email, orange for IM). You can even customize it to ignore messages from known perverts, spammers, et al. The MX610 detects when the computer is not operating and turns itself off to save battery power, and it can change channels automatically if there is wireless interference. It even lets you know if its own battery is low. The operating range is about 30 ft, and battery life is rated

■ LOGITECH'S MX610 MOUSE AND RECEIVER PROVIDE CORDLESS OPERATION UPTO 30 FT FROM THE COMPUTER.

at three months with regular use. And, of course, laser tracking gives you more accurate performance on a wider variety of surfaces. So if you're looking for something that goes way beyond standard roll-and-click operation, you can pick up this little rodent for \$59.95.



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You may use Google as a search engine but, in case you haven't noticed, the company also offers a range of satellite imaging services, some of which are free. Just point to any place on the globe you want to explore, and the service — called Google Earth — brings up images and local facts. You can even look at a specific address, get driving directions, and simulate a flight along the route to your destination.

You can try it out by logging onto earth.google.com and downloading the basic software at no cost. Or, for \$20, you can upgrade to Google Earth Plus, which adds GPS device support, spreadsheet import capabilities, drawing tools, and improved printing capabilities. Or if your wallet is especially fat this month, you can even get Google Earth Pro for \$400. Geared for professional and commercial applications, the Pro version offers bells and whistles too numerous to list here. The main catch is that there isn't presently a Macintosh version, and it may not be operable on Windows-based desktop PCs older than four years and notebook PCs older than two years. You'll need — at the very minimum — Windows 2000 or XP, a 500 MHz CPU rate (2.4 GHz recommended), and a 3D graphics card with 16 MB VRAM. And, if your machine has an ATI Rage Mobility, ATI Xpert, or ATI 3D Rage card, forget it. For complete information, visit the site.

>>>> INDUSTRY & THE PROFESSION

STUDY TENDS TO CLEAR CELL PHONES

Scientists from the UK's Institute of Cancer Research (www.icr.ac.uk) recently published the results of an investigation into the relationship between mobile phone use and the risk of acoustic neuroma, a nervous system tumor that occurs close to where mobile phones are held to the head. Acoustic neuromas are benign tumors that grow in the nerve that connects the ear and inner ear to the brain. They often cause loss of hearing in the affected ear and inner ear and a loss of balance. However, acoustic neuromas are usually slow growing and do not spread to other parts of the body.

Data were collected from 678 people with acoustic neuroma and a control group of 3,553 people who did not have the affliction. Participants, who were residents of the UK, Denmark, Finland, Norway, and Sweden were asked in detail about their past mobile phone use (e.g., length and frequency of calls, makes and models of phones used, and extent of hands-free use) and also about other factors that might affect their risk of acoustic neuroma. The study found no relationship between the risk of acoustic neuroma and the number of

years for which mobile phones had been used, the time since first use, the total hours of use, or the total number of calls, nor was there any distinction between analog and digital phone use. However, the results did not give a clear interpretation for the risk of tumors after use of a phone for 10 years or longer, so an increased risk over a greater time span could not be ruled out. But, for now, you can probably keep it glued to your ear without any misgivings.

NEW JOURNAL ON DISPLAY TECHNOLOGIES

It won't be everyone's cup of tea, but if you work extensively with devices that employ electronic displays, you may be interested in a new journal published jointly by the *Institute of Electrical and Electronics Engineers* (IEEE) and the *Optical Society of America* (OSA). The quarterly *IEEE/OSA Journal of Display Technology* covers theory, design, fabrication, manufacturing, and application of information displays, as well as aspects of display technology that emphasize progress in device engineering and design, materials, electronics, physics, and reliability. Subscription details are available at sscs.org/pubs/j-dt.htm.

>>>> CIRCUITS & DEVICES

HIGH END DIGITAL CAMERA

If you have been waiting for a professional quality digital camera to come in below the \$1,000 level, your time has come. Slated to be in stores sometime this month is Sony's Cyber-shot R1, billed as "The world's first integrated lens digital still camera to combine a professional-grade, 10.3-megapixel image sensor and the flexibility of live preview while shooting." Unlike digital SLRs, this unit's sensor allows for a "live" preview, thanks to Sony's improved CMOS technology. Until now, the high power consumption of such large sensors has limited their operation to image capture only, unable to support the benefit of a live preview. The camera's electronic viewfinder or two-inch LCD lets you evaluate scene

conditions, such as exposure and how color is rendered, before taking a shot.

The camera is fitted with a Carl Zeiss Vario-Sonnar lens that zooms from 24 to 120 mm, and the live sensor capability eliminates the need for a mirror and prism. This allows a lens-to-sensor distance of as little as 2 mm, providing better image quality and color accuracy. It also makes for quiet operation. Other features include a one-second shot-to-shot time, three-frame-per-second burst shots, and a shutter release time of only

7.5 msec. The low power consumption allows a battery life of up to 500 shots per charge. For more

details, visit www.sony.com/r1 or check with your local dealer.

■ SONY'S CYBER-SHOT® R1 OFFERS 10.3-MEGAPIXEL RESOLUTION AND A "LIVE" PREVIEW.

PHOTO COURTESY OF SONY ELECTRONICS.

MICROSTEPPER MOTOR CONTROLLERS INTRODUCED

Allegro MicroSystems, Inc. (www.allegromicro.com), has introduced a new family of Sanken unipolar microstepping two-phase constant-current motor driver ICs that feature a built-in sequencer. The SLA706xM series is a complete unipolar microstepping motor driver family with a built-in translator designed to operate unipolar stepper motors with a simple step input. There is no need for phase-sequence tables, high-frequency control lines, or complex interfaces to program.

Useful for half, quarter, eighth, and sixteenth microstepping, the family is made up of models SLA7060M, SLA7061M, and SLA7062M. The series includes a PWM constant-current control method, synchronous PWM chopping function for two phases of motor coils to prevent motor noise at the hold mode, and a sleep mode for reducing the IC input current in standby mode.

The devices are primarily targeted toward applications in robots, copy machines, and scanners. They are configured in a 21-pin single in-line power-tab package and are priced from \$1.92 to \$2.35.

■ NEW FAMILY OF MOTOR DRIVERS IS APPLICABLE TO ROBOTICS AND OTHER APPLICATIONS.

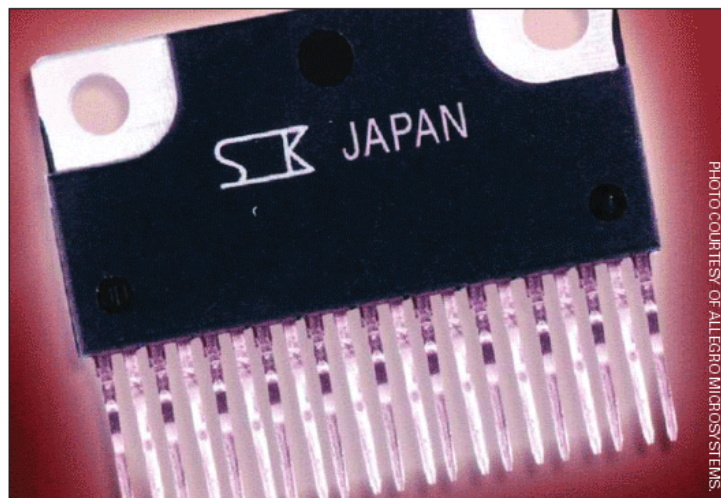


PHOTO COURTESY OF ALLEGRO MICROSYSTEMS.

SINGLE-CHIP LIGHT SENSOR Intersil Corp. (www.intersil.com) has introduced the EL7900, an optical sensor that converts light to current. The device operates in lighting conditions from 1 to 10,000 lux, generating information that can be used to determine the amount of ambient light present, which allows automatic backlight or brightness control for backlit keyboards and LCD monitors. This allows devices such as cell phones, laptops, and other handheld devices to decrease overall system power consumption by dynamically controlling the current sent to the display or backlight. Designed to operate within a temperature range of -40 to +85°C, it includes both photodiode and amplifier. Suggested price in 1,000-unit quantities is \$0.70. ■

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HOW THE PAST AFFECTS YOUR FUTURE

THE ATARI 2600

>>>The Glory Days of the Cartridge Family

Remember the 1970s? Vietnam, Watergate, stagflation, polyester, bellbottoms, John Denver, gas rationing, *Saturday Night Fever*, and other events that made that decade, at least in retrospect, seem like 10 disheartening, frustrating years. But a few lasting bright spots emerged, as well. The personal computer was one of them.

Its less sophisticated but more fun-loving younger brother, the video game, was another. Of course, there's one name and four digits that are synonymous with videogames in the 1970s: the Atari 2600. In 1971, Nolan Bushnell left his \$12,000 a year job at Ampex to create video games. After a false start attempting to convert Spacewar, a mainframe-based game, to a coin-op version that failed due to its complexity, Bushnell swung in the opposite direction, and created Pong.

Unlike its complex predecessor, Pong was the *I Love Lucy* or *Honeymooners* of video games. Black and white, one set, tiny cast, no special effects, minimal action, and totally addicting. The game's sole instruction was: AVOID MISSING BALL FOR HIGH SCORE. *No wonder it launched such an empire.*

Ultimately named Atari, from the classic Japanese board game Go, Bushnell and his company created home versions of Pong, but it was awhile before the concept took off. Eventually, the engineers at Atari hit upon the concept of a game system with interchangeable cartridges. Bushnell says, "The economics looked really good. I mean, the razor/razorblade marketing always tended to work, and in addition to that, we felt that people wanted that variety, and that was the way to give it to them."

Thus, the Atari 2600 Video Computer System was released in late 1977. In the previous year, Warner Communications had purchased Atari for \$28 million, based on its early console sales, and the success of Atari's coin-operated game division. For a while, Atari was a drain on Warner's resources, as initial sales of the 2600 were respectable, but not spectacular.

Then, in 1980, Warner bought the home rights to Space Invaders, a smash hit of a coin-op game, from Midway. Suddenly, Atari, and the whole home video game industry, had its killer app. At the time, with the cable television industry just starting to take off, so many people were playing Atari, that it was known as "the fourth television network."



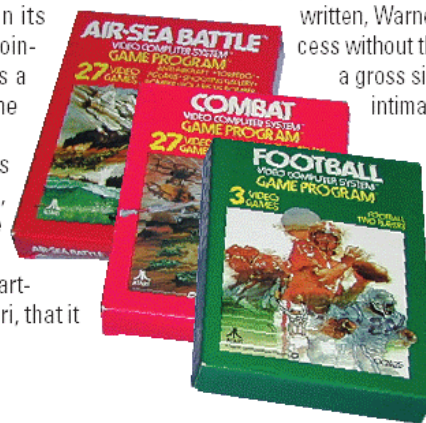
■ ATARI VCX CX2

The 2600 soldiered on, even after Bushnell left Warner in 1978 and in the face of increasingly complex opposition, such as Mattel's Intellivision and Coleco's eponymously-named ColecoVision cartridge systems. After leaving Atari, Bushnell created the Chuck-E-Cheese restaurant franchises in the early 1980s, and today is involved in a variety of entrepreneurial ventures, many of which revolve around his first love, video games.

1982: THE YEAR OF LIVING DANGEROUSLY

By 1982, back at Atari, video games were hot, even making the cover of Time magazine. But the 2600's aging technology and its rapacious exploitation by Warner caught up with each other. Pac-Man was the beginning of the end for the 2600's glory days. Warner Communications gave Todd Frye, the programmer assigned to translate Pac-Man into an Atari cartridge, three months or less to get the job done, and offered him a million dollar check, plus royalties, to do it.

Frye wanted Atari to use an 8K memory chip, not the 4K chip that Atari used for most of their cartridges (early 2600 cartridges used only 2K of memory!). Although the 8K chip would have allowed a better program to be written, Warner decided that the well-known title would guarantee success without the extra effort and cost. Unfortunately, the end result was a gross simplification of a game that millions had played and knew intimately. It wasn't even close to the original coin-op game.



1984 AND BEYOND: THE CRASH AND ITS AFTERMATH

The Pac-Man debacle foreshadowed bigger problems ahead. By 1983, Atari's monopoly-like status as *the* video game

system was drawing to a close. Competitors' technology had caught up with it, a glut of videogames flooded the market, and magazines had sprung up with video game reviews, meaning people didn't blindly purchase Atari products. The result was that, as 1929 was to the stock market, 1984 was to the video game industry. A deep depression occurred, leaving many wondering if it would survive. At Atari, the number of employees fell from 10,000 in 1982 to just 200 in July 1984.

Obviously, the home video game industry did survive, but with radical changes. With Atari and other US companies eventually neutered, Japanese-based businesses, such as Nintendo and Sega, were able to clean up for the rest of the 1980s and into the 1990s. Significant American competition didn't arrive until Microsoft's Xbox.

The year 1984 also marked the year that Atari split up. The consumer division went to Jack Tramiel, the founder of Commodore, who focused his efforts on Atari's personal computers in order to compete with his old company. Atari's arcade division stayed with Warner Communications for a while, and eventually became Time-Warner Interactive, which sold it to Midway Games, Inc., the coin-op manufacturer. Midway recently discontinued the name Atari for its coin-op games, possibly marking the end of the line for the name Atari in the arcades.

In 1996, Jack Tramiel's Atari merged with JTS, a disk drive company, which eventually went out of business. In 1998, Hasbro bought the rights to its home titles. And, in 2000, Hasbro sold the rights to their Atari titles to Infogrames, Inc., which has since changed its name back to Atari (and their website's URL is www.atari.com).



■ LATER GAMES

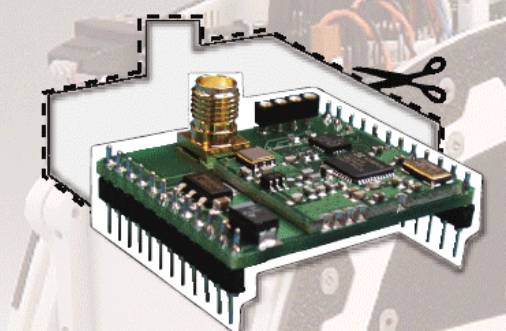
THE 2600 IN THE PC AGE

The spectacular growth of both PCs and the Internet has created several options for fans of the 2600 who want to recreate its heyday. eBay typically has a vast collection of 2600 games, accessories, and even whole systems available for purchase, mostly used. New and used equipment can be purchased from Telegames, Inc. (www.telegames.com), Best Electronics (www.best-electronics-ca.com), and others. O'Shea Ltd. claims it recently discovered a cache of one million 2600 cartridges, which it's selling at \$5.00 each. Check out www.atariclassic.com for details.

Several of the games, and their late-'70s, early-'80s coin-op big brothers, are available for the PC. Asteroids, Ms. Pac-Man, Centipede, Missile Command, and other classic games. Meanwhile, Hasbro and Activision have released many of the home Atari titles for the PC, as well. A search of the Web will also turn up online versions and downloadable 2600 emulators.

For die-hards like myself who remember Atari fondly, it's great to see a variety of options available to relive the glory days of the Cartridge Family. Why does the popularity of the 2600 exist to this day? Leonard Herman, the author of *Phoenix: The Fall and Rise of the Videogame Industry* (Rolenta Press; ISBN: 096438485X) says, it's "the same reason why old music's popular, old paintings are popular: it's an innocent art form. What Atari did with those games was, that because it had so much more of a limited memory, they had nothing for graphics, so everything that they put into it was to make the games fun." ■

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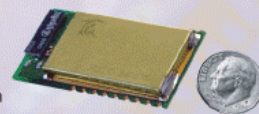
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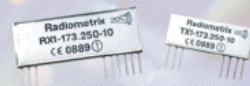
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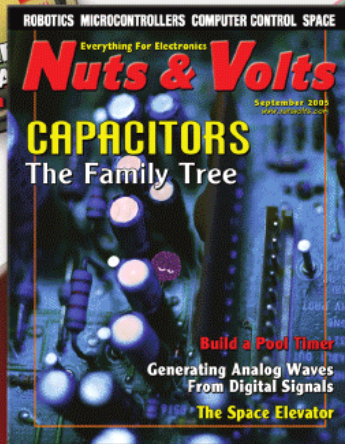
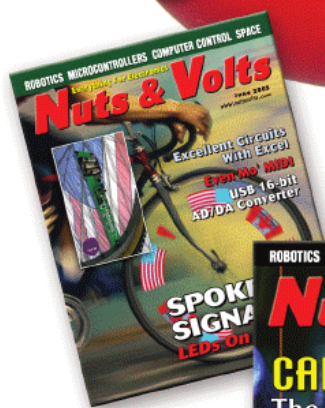
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Q&A

WHAT'S UP:

I can see it's back to school from this month's questions.

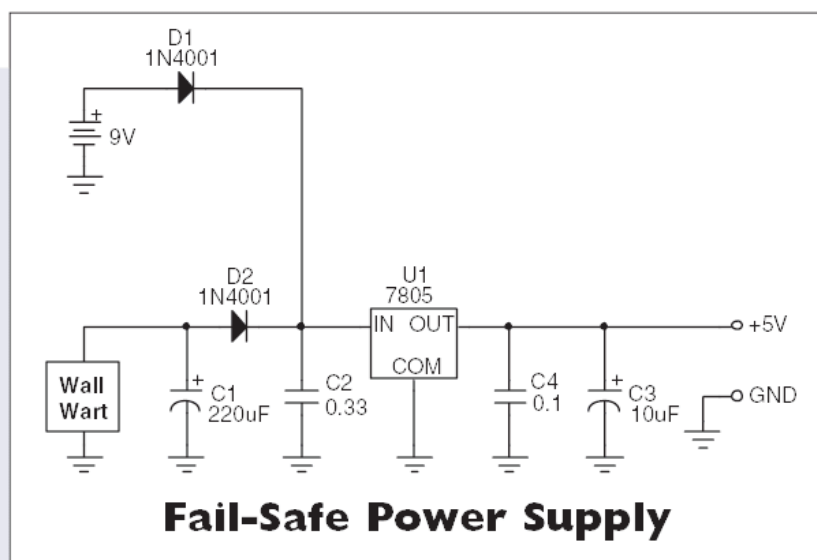
- ✓ Plan on learning about CCFLs, degaussing, and signal sampling.
- ✓ How about the best way to build a 78xx power supply from scratch or putting a PIC to sleep?
- ✓ And there's more.

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Fee free to participate with your questions, comments or suggestions.

You can reach me at:

TJBYERS@aol.com



■ FIGURE 1

BATTERY BACK-UP POWER SUPPLY

Q I'm trying to design a five-volt power supply that is backed up by a nine-volt battery in case of power loss. Would you please look at my design and let me know if it makes any sense? D1 is to protect the battery from being charged by the external wall wart 12-volt

DC power supply. During battery operation, D2 will prevent current from flowing back into the wall wart. Your feedback is greatly appreciated.

■ Fred, via Internet

A You have a good design, and it will work. However, if you rearrange the parts just slightly, you can get better performance from the 7805 regulator. Specifically, C2 and C4 should be physically as close to the regulator as possible. This will improve the transient response of the power supply.

I would also put C1 on the other side of the D2 isolation diode for the same reason. Take a look at Figure 1 for details.

SLEEP, PIC, SLEEP

Q I have a few projects built around PIC microprocessors, but they all require an on/off switch to apply battery power. Can you suggest a circuit or IC that will automatically switch the battery off (or go into a low power mode) if there is no I/O activity in a set time period?

■ T. Campbell, Austin, TX

A It is done in software using the built-in timer and a call to the Sleep command. The PIC may be powered down to as little as 50 mA, and later powered up using an interrupt. Here's a typical routine (you provide the code). Other routines are possible and vary according to the application.

To create a Sleep Timer:

Start a counter (typically TIMER0) Use it to drive a countdown loop If a change on input pin GP0, GP1, or GP3 occurs before TIMER0 = 0, reset TIMER0
If TIMER0 = 0, issue SLEEP command

To wake up from Sleep:

Look for a change on input pin GP0, GP1, or GP3

Here are some things to consider when writing this routine. If Sleep is enabled, the oscillator and TIMER0 are turned off. The Watchdog Timer (WDT) will be cleared but keeps running, the TO bit (Status bit 4) is set, and the PD bit (Status bit 3) is cleared. The I/O ports maintain the state they had before the SLEEP instruction was executed. It should be noted that a reset generated by a WDT time-out does not drive the GP3/MCLR/Vpp pin low. For lowest current

consumption while powered down, the T0CKI input should be at VDD or VSS and the GP3/MCLR/Vpp pin must be at VDD (logic high) if MCLR is enabled.

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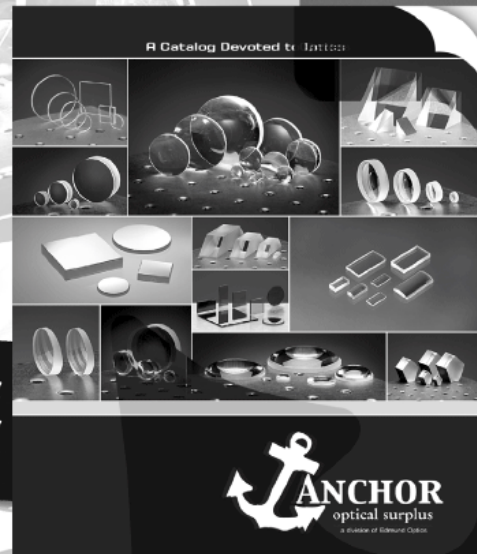


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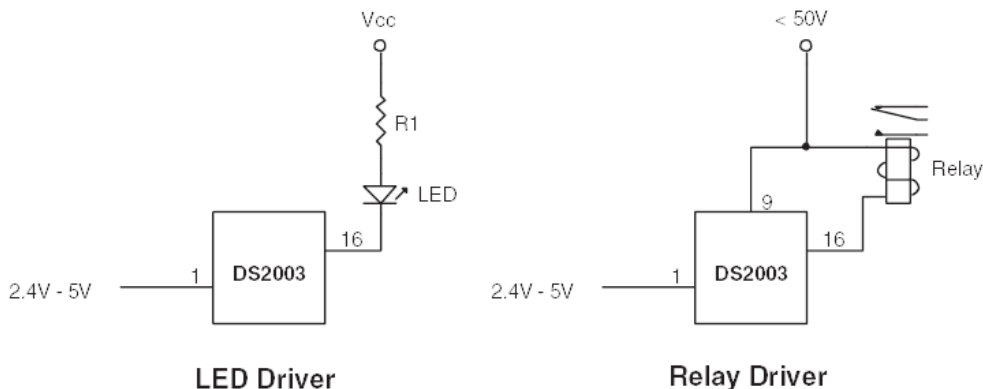


>> IC DRIVER BEEFS UP MCU OUTPUT

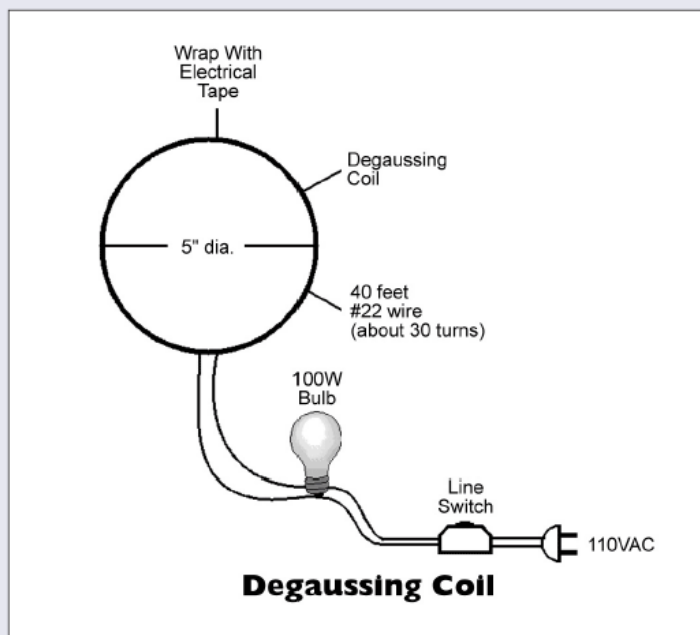
Q I am experimenting with the Rapid Virtual Hardware Engineering Tool that I bought from AI Applications through an ad in *Nuts & Volts*. It's pretty neat, with an on-board Basic interpreter that makes I/O effortless. But the I/O pins just handle 4 mA, so I need you to recommend a driver chip I can use to interface the MCU with LEDs, relays, and so forth. I can do it with 2N3904 transistors, but a chip would be better. The working voltage is 3.3 volts. ■ *Harvey Lewis, via Internet*

■ FIGURE 2

A I contacted National Semiconductor and they recommended the DS2003, a high-current (350 mA) Darlington driver. Inside this 16-pin package are seven drivers with reverse diode protection for inductive loads up to 50 volts. It comes in several packages, including MDIP and SOIC, and is available from several sources for about \$1. Figure 2 shows typical DS2003 applications for LED and relay loads.



DS2003 Applications



■ FIGURE 3

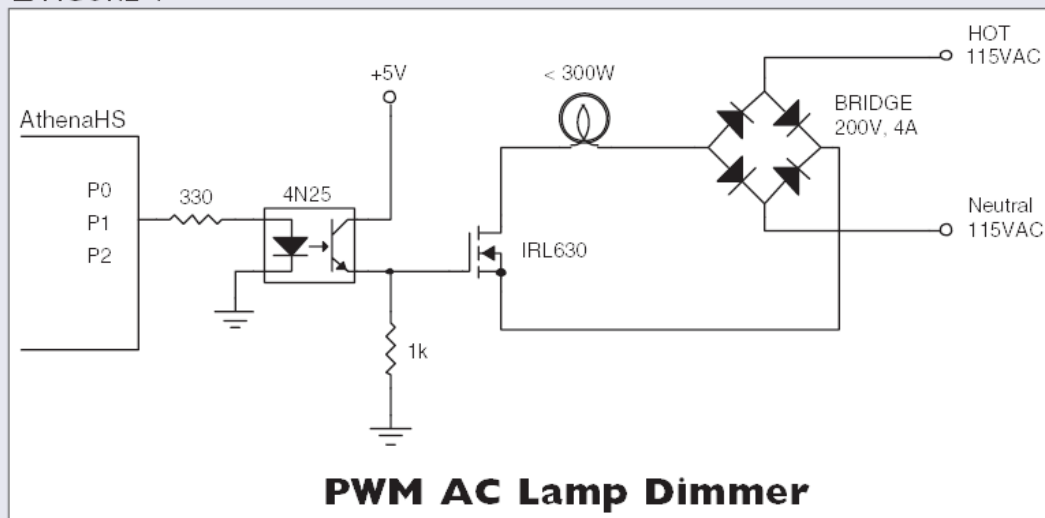
The PIC can wake up from Sleep by any of the following events:

1. An external reset input on GP3/MCLR/Vpp pin.
2. A Watchdog Timer time-out reset (if WDT was enabled).
3. A change on input pin GP0, GP1, or GP3.

The WDT is cleared when the device wakes up from Sleep, regardless of the wake-up source. When the Sleep instruction is executed, the next instruction is pre-fetched. When the PIC wakes up, that instruction is run. In cases where the execution of the instruction following Sleep is not desirable, the user should insert a NOP after the Sleep instruction.

Now before I get flooded with PIC programming questions — I'm not a PIC programmer. So don't ask me to debug your code — not even for money! I just dabble in PIC programming from time to time, and have learned that the best way to program a PIC using assembly language is to acquire a library of routines and make calls to them as needed. Karl Lunt has a good library of PIC macros located at

■ FIGURE 4



DEGAUSSING COILS

Q Could you explain the use of a degaussing coil, and tell me if it can be used as a loading coil for an antenna?

■ Len, via Internet

A Let's start with the degaussing coil and go from there. All cathode ray tubes (CRT) have a metal screen called a shadow mask mounted just behind the face of the tube that provides the focus aperture for the three (RGB) color guns. If the mask becomes magnetized, the color purity and focus of the image starts looking like a kaleidoscope or psychedelic trip from the '60s. Even moving the monitor or TV set from one room to another can cause the Earth's magnetic field to change the magnetic properties of the shadow mask.

When this happens, the shadow mask needs to be demagnetized using a degaussing coil, which is nothing more than a few turns of wire that generate an alternating magnetic field. Virtually all CRT monitors have a built-in degaussing coil that activates for a few seconds every time you turn the set on.

However, the field that the built-in degausser generates is not always strong enough to erase really strong magnetism from localized areas of the mask—like when the grandkids discover your fridge magnets. For that you need a hand-held degausser — which sells for \$40 to \$60.

Fortunately, you can make one for under \$10 (free if you can scrounge the parts!). A degaussing coil is nothing more than a large coil of wire that you plug into the AC wall outlet. The coil is made by winding many turns of magnetic wire (the kind found in a discarded washing machine motor) in a circle. The wire size should be 22 gauge (AWG) or larger, and can be purchased from RadioShack (part number 278-1345). Wind the coil around a five-inch form — something like a small stove pot. A precise diameter isn't important; anything close will work.

Remove the coil from the form using a few strips of electrical tape to keep it from unraveling. Solder two wires to the end of the coil — lamp cord works fine — and insulate the splice with shrink tubing or electrical tape. Now completely cover the coil with a layer of electrical tape to protect yourself from electrical shock. Leave no bare wire showing! Because the wire has a very low resistance, you will need some kind of current limiter in series with the coil. I find a 100W light bulb to be just perfect (Figure 3).

Finally, install a line switch and a wall plug. An extension cord from the local grocer works well.

To use the degausser, plug

the coil into the AC outlet with the switch OFF. Flip the switch on, bring the coil against the screen of the CRT, and move the coil around in slowly widening circles until it covers the edges of the CRT.

At this point, slowly back the coil away from the screen until you're about two to three feet away. Turn off the degausser. You can do this with the monitor/TV turned off, but then you'll lose the best part of the show. Having the set on doesn't affect the degaussing. During this operation, the coil heats up quickly, so never run the device for longer than 30 seconds.

Finally, remember you are holding a live AC wire in your hand, so take every precaution to avoid a burn or shock!

As for using the degaussing coil for an antenna load, if you have a degausser that you have salvaged from an old TV or monitor, you might be able to use the copper wire to wind an antenna loading coil — provided the wire is large enough to handle the antenna current.

GOING FROM POOL TO PATIO

Q I had the pleasure to build and enjoy the "Floating Light Show" project that was in the September 2004 issue. Now I'd like to transfer that lighting experience to my patio using PAR 38 fixtures. Could you provide a circuit to supply power to the project with a wall wart and also to send the outputs to three triacs for the red, blue, and green floodlamps?

■ Dennis Isaacs, Fairfield, TX

A The power supply is the simple part — just use the one described previously in the question "Battery Back-Up Power Supply." (You can ignore the battery because it doesn't have enough energy to light the floodlights.)

Interfacing the Athena microcontroller (MCU) outputs to a triac, though, is another story. The MCU uses pulse-width modulation (PWM) to control the brightness of the LEDs. While this method is the same one that is used with triacs to dim incandescent lamps, the PWM signal must be synchronized to the line frequency to work. The MCU in the "Floating Light Show" isn't synchronized. For that to happen, you need to rewrite the code and have a sync input from the AC line.

Why go to the trouble when you can substitute a power MOSFET for the triac and have it drive the floodlight directly? I asked myself the same question and came up with the circuit in Figure 4. Of course, I used a 4N25 optoisolator to keep the AC line separate from the MCU. The 4N25's output transistor

translates the PWM signal to the gate of the MOSFET, which causes the incandescent lamp to respond as it would with the LED. However, MOSFETs are DC operated, which is the reason for the bridge rectifier. I know the DC voltage isn't filtered, but at 120 Hz you'll never notice the variations in the asynchronous switching times. The floodlamp has a very slow response time. By the way, you need three drivers for the RGB but only need to tap into the P0, P1, and P2 output pins to get the desired effect.

The circuit is simple and open to part substitution. But don't be tempted to replace the IRL630 with a garden-variety MOSFET. It's one of few that saturates at five volts; most require 10 volts for switching operation. Using a 10-volt gate-operated MOSFET in this

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circuit means it will spend a lot of time in the linear region, which leads to a lot of heat and the ultimate destruction of the transistor.

COLD-CATHODE FLUORESCENT LAMPS

Q What is a cold-cathode fluorescent lamp (CCFL)? Is there a significant difference between it and the normal fluorescent lamp regarding theory of start-up and operation, efficiency, and lifetime?

■ M. John, via Internet

A Except for size and shape, they are identical — with the exception of the cold-cathode feature. Your standard 40-watt T-8 lamp has a filament at both ends of the four-foot tube. When the lamp is started, the filament(s) is turned on momentarily to vaporize a small bead of mercury placed at the end of the tube. A CCFL lamp, on the other hand, has no filament. Instead, it relies on a high-voltage surge — typically 1,000 volts — to “spark” the residual mercury vapor to life.

Once the gas is ignited, it turns into plasma, which changes the lamp from an insulator to a conductor that emits ultraviolet light. A thin layer of fluorescent material coats the inside of the tube — a mineral that glows when activated by an ultraviolet source. Different minerals glow different colors.

The mercury tube now becomes a negative-resistance device that is better described as akin to a zener diode. The lamp is now a

current operated device where the amount of current determines the brightness; the operating voltage drops down to about 200 to 300 volts.

It used to be that CCFL tubes were most often found in laptop computers as backlighting for the liquid-crystal display (LCD). That role is now being filled by ever-increasingly efficient LEDs. LEDs have a life span of 100,000 hours, as opposed to the 5,000 hours of a CCFL lamp. The new niche for CCFL devices is as decorative lighting inside PC cabinets and under the hoods of Toyotas.

Fortunately, the technology is well advanced and the components are easily found on the surplus market; All Electronics (888-826-5432; www.allelectronics.com) has a good selection at bargain prices. What you need to play with CCFL tubes is a small DC-to-AC inverter and the tube itself. Don't be tempted to make the inverter yourself — it will cost you more. They sell for less than \$10, CCFL included.

NYQUIST SAID IT FIRST

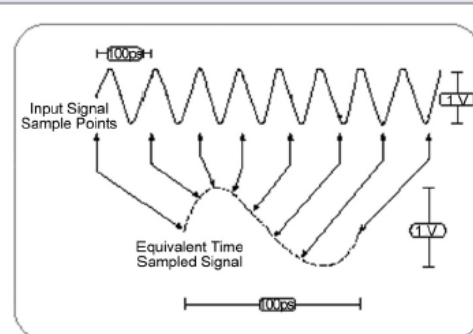
Q I have heard that there is a way to be able to read higher frequencies on an oscilloscope than those for which the oscilloscope was built. I was wondering what circuit or devices are needed to accomplish this task.

■ Dustin Enns, Lehigh, KS

A What you are talking about is sampling. That is, you sample small parts of a series of waves to reconstruct them. Confused? Look at Figure 5. Most scopes have two different sampling rates (modes) depending on the signal being measured: real time and equivalent time sampling — often called repetitive sampling. However, sampling

only works if the signal you're measuring is stable and repetitive because this method works by building up the waveform from successive measurements. When sampling a signal, the sampling frequency must be greater than twice the bandwidth of the input signal in order to be able to perfectly reconstruct the original from the sampled version.

Otherwise, the frequencies will overlap — a condition called aliasing — where the reconstructed waveform has nothing at all in common with the original signal. The aliasing failure was first formulated by Harry Nyquist in 1928 and is (duh) known as the Nyquist theorem. For an in-depth discussion on sampling and other oscilloscope-related facts, read Tektronix's *XYZs of Oscilloscopes* that you can find on the *Nuts & Volts* website (www.nutsvolts.com) under XYZs_OSCILLOSCOPE.PDF. ■



Sampling a repetitive waveform allows you to display a signal on the oscilloscope that exceeds the bandwidth of the instrument itself.

■ FIGURE 5

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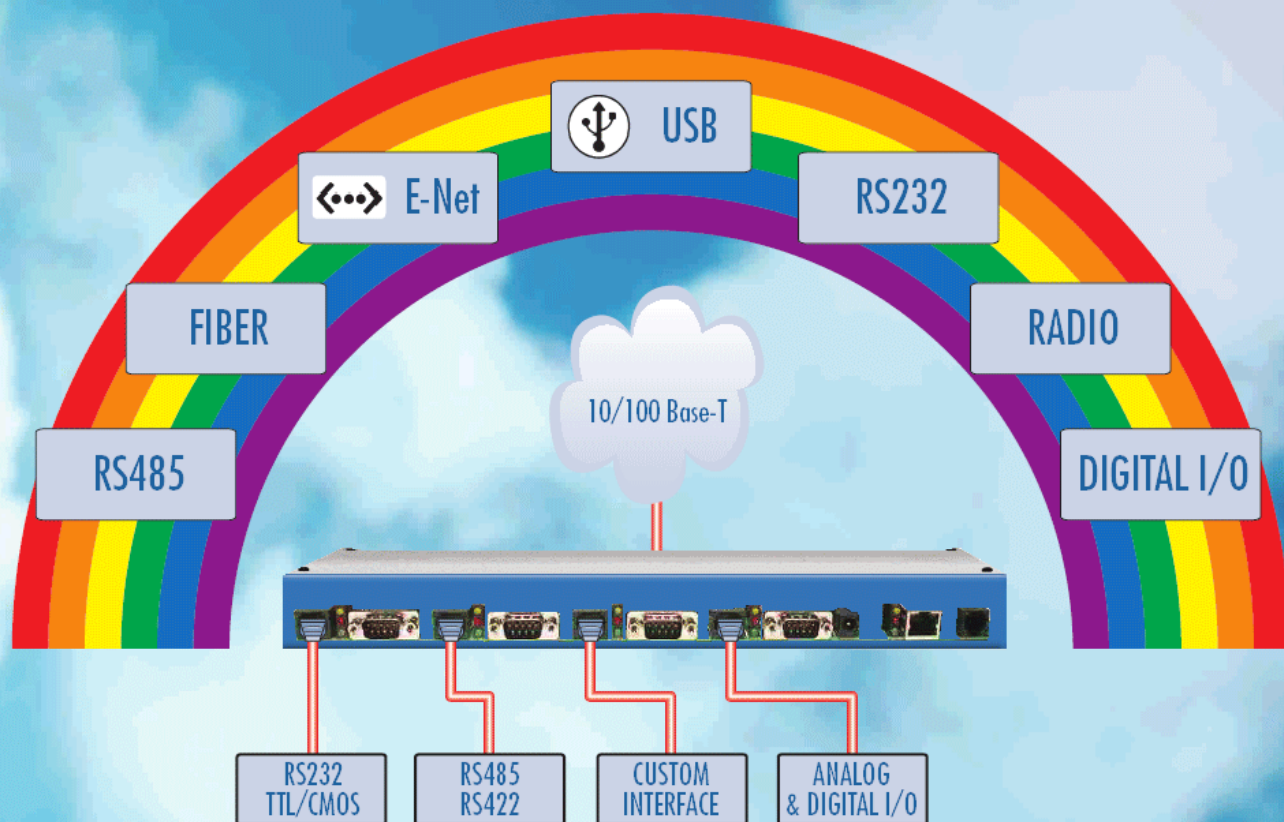
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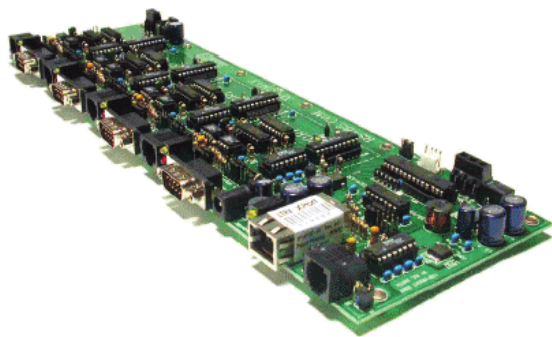
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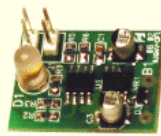


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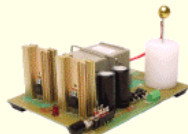


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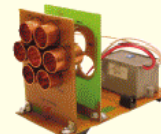


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BS2C Bullshooter-II Kit 69.95

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Find that transmitter quick!

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DDF1 Dir. Finder Kit 169.95

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For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 Series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use.

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is available in either white or black. (Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).

FM30	Digital FM Stereo Transmitter Kit, 0-25mW White	\$199.95
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Professional Synthesized Stereo FM Transmitter

- ✓ Fully synthesized 88-108 MHz for no frequency drift
- ✓ Line level inputs and output
- ✓ All new design using SMT technology

Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer!

A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's "digital" receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, easy assembly instructions, and the SMT parts are factory preassembled - you'll be on the air quick!

FM25B	Professional Synthesized FM Stereo Transmitter Kit	\$139.95
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Tunable FM Stereo Transmitter

- ✓ Tunable throughout the FM band, 88-108 MHz
- ✓ Settable pre-emphasis 50 or 75 µSec for worldwide operation
- ✓ Line level inputs with RCA connectors

The FM10C has plenty of power to cover your home, back yard, or city block. You'll be amazed at the exceptional audio quality of the FM10C. Tunes through the entire 88-108MHz band. Re-broadcast your favorite music commercial free and with the dynamic range the musician intended, without all that nasty compression the big boys use to make their station sound louder than the competition. Compression produces a noticeably muddier and less dynamic sound. Runs on an internal 9VDC battery, external 5-15VDC, or our FMAC AC power adapter.

FM10C	Tunable FM Stereo Transmitter Kit	\$44.95
FMAC	110VAC Power Supply for FM10C	\$9.95

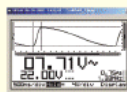


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- ✓ Digital waveform and measurement display!
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- ✓ Backlit LCD display
- ✓ RS232 output (40MHz model only)
- ✓ Charger, case, probes included



We've seen a lot of portable scopes and scope/meters, and we've also seen the price tags! They have always been way out of the reach and budget of the hobbyist. No more! Now for close to the price of a good DMM you can have a personal scope that also has DVM readout for dBm, dBV, DC, and True RMS! Frequency readout is also displayed on the screen through markers, plus the scopes have two memories for digital storage.



The 40MHz model also includes an RS232 output and serial interface to capture the screen display on your scope to your PC at the mere push of a button! These scopes run on 5 standard AA Alkaline batteries (not included) which provide up to 20 hours of use. You can also use rechargeable AA NiMH batteries instead and they'll be charged with the optional power supply. Both units come with a custom foam lined high impact carrying case, set of high quality scope probes, AC power adapter and a comprehensive user's manual. If you're working with electronic circuits, automotive applications, audio and stereo applications or other applications, the personal scope is for you...at a price that can't be beat!

HPS10SE	Personal Handheld 10MHz Digital Scope	\$229.95
HPS40	Personal Handheld 40MHz Digital Scope w/RS232	\$299.95

Audio/RF DDS Signal Generator

- ✓ DDS and SMT technology!
- ✓ Frequency range 0 Hz to 5 MHz with 0.1Hz resolution!
- ✓ 0 to 10V peak to peak output level
- ✓ Sine, Square, or Triangle waveform output!
- ✓ Non-volatile memory
- ✓ Factory assembled and tested



DC to 5 MHz...In 0.1 Hz Steps!

Following in the footsteps of our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) in continuous 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

The SG560 contains a 10 bit DDS and filtering for a low noise, accurate low distortion output. The output stage utilizes the latest technology in digital modems and high power, high bandwidth DSL modems and is capable of a direct output of 2.5W! You can even generate carrier signals in the AM band for testing AM receivers and circuits. A jumper option for zero ohm output impedance allows for true output terminal metering. But watch out, 2.5 watts is enough to damage incorrectly connected circuits!

Surface mount technology is used throughout the SG560 making it extremely reliable and accurate. Frequency is entered directly on the sealed membrane keyboard and adjusted with a precision rotary encoder with an oversized knob. Both frequency and output level are displayed on a high contrast, two-line LCD display.

The SG560 operates on 8 to 16VDC and includes a standard 110VAC power adapter. Because of the surface mount design the SG560 is only available factory wired and tested. If you are looking for a lab quality signal generator at a super price, the new generation SG560 fits the bill... and a whole lot more!

SG560WT	Audio/RF Signal Generator, Factory Assembled	\$329.95
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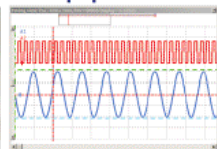
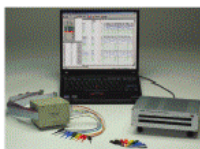
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HUMAN NATURE

IN MY COLUMN, I OFTEN REFER TO HUMAN NATURE. I think it's time to take a closer look at what actually constitutes human nature. This is important because engineers, as a group, are generally more interested in things than people. However, dealing with people in both personal and business settings is essential.

UNPREDICTABILITY AND THE FONTE PRINCIPLE

The first thing to recognize is that people are perfectly unpredictable. That's something you can bet on. Just when you think you've got someone figured out, they'll go off and do something completely bizarre. Including me.

This is based on the Fonte Principle, which says, "The behavior of any small part of a sufficiently complex system appears random." For example, if you probe a single node in a computer that is performing a complicated routine, its state can change unpredictably. It may stay at zero for hours, only to jump to one and back in a microsecond as a special case is encountered by the software (or was influenced by an alpha particle or just got bored and wanted to see what one was like). Simply put, you can't get any useful information about the whole system from looking at only one point.

Since people are usually more complicated than computers and you can never really measure their complete mental state without dissection and staining, a person's behavior will often appear random. This is especially true for teenagers, whom, due to their competitive hormone races, are forced to reinitialize their cognitive process every five minutes or whenever they think about the opposite sex. Which is every five minutes.

Unfortunately, we never completely outgrow competitive hormone races. They circulate within our bodies, vying for attention and action. This is why, when in the middle of a romantic

interlude with your significant other, you will come to realize that perfection would be a Limburger and onion sandwich. Or, perhaps the other way around. There's actually no way to be sure.

What we see is that behavior is based on likely outcomes rather than certainties. In some ways this is very similar to quantum theory, where an electron's position is never precisely known. Instead there is some probability that the electron will be found at some particular location. We can all relate to such a situation in human behavior. For example, Bob (not his real name) will be hard at work at his desk until 10:10 a.m., at which time he can be located in the bathroom.

Normally, you can set your watch by his actions. Except that last night he ate some bad oysters at dinner while trying to impress Nancy (not her real name) from purchasing (not her real department) about what a suave and sophisticated guy he was. So, his competitive hormones are now racing about, completely unsynchronized, causing his behavior to be spontaneous and unpredictable. At least until he gets the oysters out of his system.

This illustrates another mathematical aspect of behavior, one that can be compared to Chaos Theory or, more specifically, the Butterfly Effect. This is where a very small difference in the initial conditions (germs on an oyster) causes a large difference later on (Bob strikes out with Nancy). The term "Butterfly Effect" (which would be a good name for a rock band) comes from the idea that a hurricane could develop from the change in air currents from the flapping of a butterfly's wings in Africa.

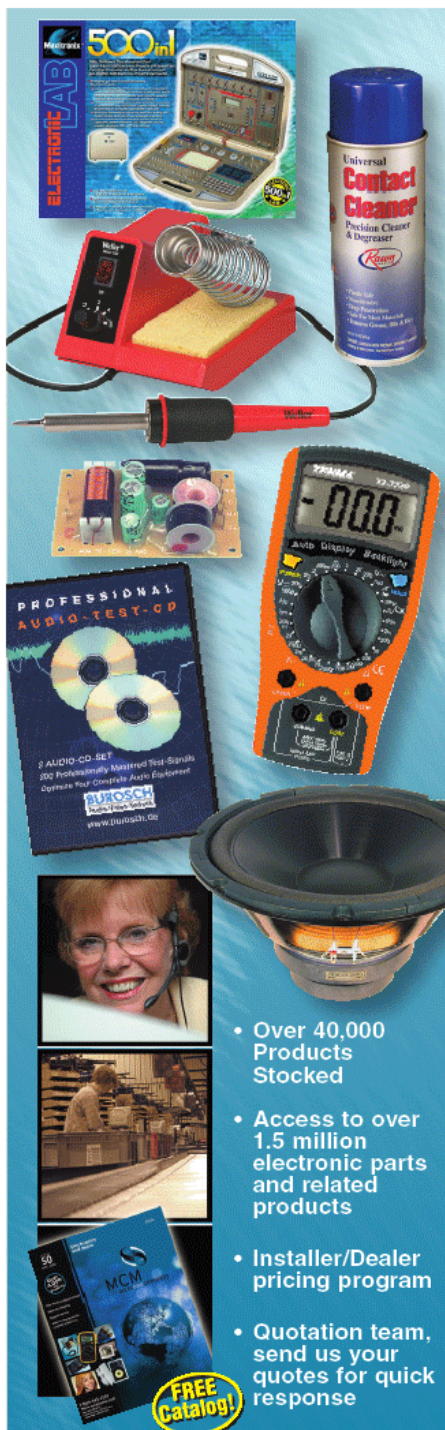
Precisely for that reason, the National Weather Service has taken action by sending thousands of fifty-cent flyswatters to Nairobi to control the weather by whacking butterflies. (Just kidding.) Those are really Mil-Spec flyswatters and cost \$458.61 each. Of course, for that price they also include a 43-page maintenance and repair manual, field training exercises, and three years of future software upgrades. They come in different camouflage patterns and the ones sent to Africa are, naturally, Arctic white.

GROUP BEHAVIOR

Group behavior is different from an individual's behavior, though we



...You can't get any useful information about the whole system from looking at only one point.



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can again apply statistical methods to better understand group behavior. The simple procedure for estimating the group's functional intelligence is to take the average intelligence and divide by the number of people in the group. For example, if you have an IQ of 115 and work alone, the average IQ of the "group" is 115. Divide that by the number in the group (1) and the group intelligence is 115.

There is a correction to this equation if members in the group are lawyers or have (only) some sort of business degree. In this situation, you must subtract the number of these people in the group from the group average, as determined above. Let's apply this to the board of directors, which consists of 10 people, including three with business degrees and two lawyers. Let's presume that their average IQ is 96. The uncorrected group intelligence becomes 9.6. (That's 96/10.) To correct for the group composition, subtract 5 from that, to get 4.6. Note that, for large groups with a high percentage of law or business degrees, this number may be negative. The signal characteristic of negative intelligence is that logic, past experience, and observed facts actually inhibit the decision making process.

The following is a transcript of a real meeting that I had the unfortunate requirement to attend (and I'm not making this up). This was a roundtable discussion and no one spoke more than once. For the record, I remained silent, even though there were times when it was nearly impossible not to scream. (Instead I simply smashed my head into the table because the wall was too far away.)

"The software operating instructions say, 'Strike any key when ready.' Any comments?"

"Well, it seems to me that 'strike' is a little aggressive. Someone might take a hammer to the keyboard."

"How about changing it to 'depress'?"

"I don't know. Isn't de-press the opposite of press? Does that mean that they should pull up on the key?"

"There are bad connotations with 'depress.' It's very close to 'depression,' which scores low on the Predictive Index of Marketing Products (PIMP). That might negatively impact sales."

"I'm concerned that someone might press RESET. That would really screw things up."

"RESET isn't a key. It's a switch on the front of the computer. You need to press control/alt/delete together to get a reset."

"But those are keys!"

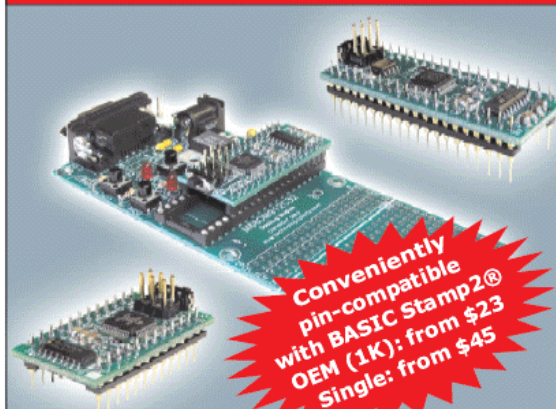
"The instructions say 'key' singular. Not 'keys' plural. I think we're safe there."

"Don't the computers we supply have physical locks that use metal keys to turn the computer on and off? If they press that key, will the software still work?"

"How about car keys or house keys?"

"Does that mean that if I forget my car keys,

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I'll have to drive all the way home and back before I can use this program?"

"Don't be silly. If you forgot your car keys you'll have to take the bus."

MALE AND FEMALE BEHAVIOR

The behavioral differences between males and females don't really become apparent until the competitive hormone races start at puberty. At this point, the males develop an inordinate interest in football and making strange noises without using their mouths. Conversely, females become fascinated with conversation and memorize all 65,536 colors, including the 4,286 that are not visible to the naked eye.

Scientists who study human behavior (called human behavior scientists) have determined that male and female behavior is so different that it is impossible for anyone to understand the behavior of the opposite sex. Which, in practical terms, is a good thing. This is because the brain has a limited capacity for understanding. Forcing it beyond that capacity would result in Xtreme Competitive Hormone Races. Believe me, there's nothing worse than hormones racing around on skateboards, jumping over capillaries, sliding down nephrons and doing 720s in the semi-circular canals. (Although the Nephron Sliders would be another good name for a rock band.) The divergent behavior between males and females can be seen in the grocery store while purchasing bathroom tissue. Females buy it by the case. Males buy it, if possible, by the sheet.

Actually, men aren't quite that bad. Generally, they keep one roll in reserve. Thus, they buy a roll at a time. Ladies, if you see an interesting man in the grocery store buying just one roll of tissue, you can be sure that he's single. However, if he's buying two rolls, that indicates one of two things. Either he ate some bad oysters recently or else he completely ran out. (Which means that he may be getting his shower curtain dry-cleaned.) More than two rolls means that there's a lady in the house. Act accordingly.

Another behavioral difference is in wrapping presents. Women have an innate ability to take any package and wrap it without any visible seams and without any adhesive tape at all. It doesn't make any difference if the package is square, round, cylindrical, or articulated. Before you can read that it was Made in China, it's perfectly wrapped.

Surprisingly, men — even with their experience in using tools for repairing cars, toasters, and plugged plumbing — are simply incapable of wrapping any present. The paper gets wrinkled, the seams are crooked, and it's all held together with three rolls of duct tape.

Take my neighbor, for example (and I'm not making this up). He was a brain surgeon. And a good one, too. I had the occasion to observe him as he tried to wrap a sweater that

was in a box. He looked like he had never held scissors before. He actually cut off a piece of his shirt while holding the wrapping paper against his chest while cutting. There were a number of places on the "finished" present where the tape was sticky side out and the paper was the wrong side in. Lastly, embedded in the tape, were several large tufts of chest hair.

CONTRARY BEHAVIOR

Humans are the only animals that deliberately choose to ignore warnings and proceed to injure themselves, whereupon, they claim that they weren't properly warned. How many times have you passed a wet paint sign at work only to touch the wall to verify that the paint was, indeed,

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wet? Then you "accidentally" wipe your fingers on your slacks and pretend that there was no sign and apply for a reimbursement from the company for new clothes. You rationalize your behavior by thinking, "If they really didn't want anyone to touch the wall, they should have blocked the hallway." Of course, you conveniently overlook the fact that this particular hallway is the only one leading from the front door. Naturally, if you had to walk all the way around the building to enter, you would have cursed those morons who didn't have the brains not to touch wet paint.

At this point, I must warn every reader that the following is dangerous to life and limb. You should never, repeat never, build a Shock-Box. I will describe it in detail so that, during any period of random behavior, if you find yourself building something unknown, you will recognize what it is and that your actions are dangerous and will immediately cease your construction.

A Shock-Box consists of a cardboard box at least one foot per side. One side, the back, is open and admits light. In the front, two holes are cut about five inches apart (or 479.5763 centipedes). These holes are sized to snugly fit empty bathroom tissue rolls. (Guys, you can use an empty paper towel roll cut in half.) Everything is painted black except large, bright red letters that read, "Warning! Shock Hazard! Do Not Look!" Lastly, you hang a picture in the box that has your boss's face transferred onto Wilford Brimley's body sporting a tube top and tiger-striped thong (check eBay for availability). That's Wilford wearing the thong, not your boss. Of course, if you have a picture of your boss in a thong, you should change the head to Wilford Brimley. Leave the Shock-Box unattended in the cafeteria.

If you should build this, even after I insist that you don't, you will observe a few things. The first is that nearly everyone will stop and look, heedless of the warning. The second is that they will be shocked at the

sight. The third is that if your boss finds out, you will be fired. That's assuming that your boss has a good sense of humor. If not, you may get a midnight visit from Bruno and Vinnie. Don't say I didn't warn you!

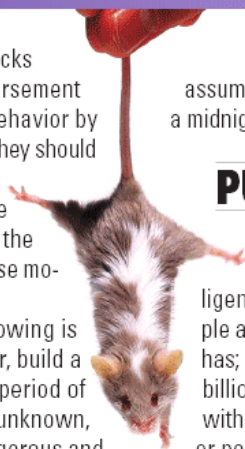
PURSUIT OF HAPPINESS

One thing that separates man (and woman) from beast, besides the fact that beasts generally have higher group intelligence due to a lack of beast-lawyers and accountants, is that people are never satisfied. It doesn't make any difference what a person has; it isn't enough (except for the number of kids). Someone can have billions of dollars and still feel the need for more. Are you satisfied with your salary or position? Would you like to have that same salary or position forever? I would gladly give every truly satisfied person a dollar if I could get 10 cents from everyone who was unsatisfied.

You don't see monkeys exhibiting this behavior. They're happy being monkeys. They enjoy climbing trees and eating the fleas that they pick off of each other. They don't care if they can't fly to the moon or if the chimp next door has more bananas than they do. They're happy being themselves.

Compare that to Donald Trump. He's managed to make millions of dollars, even after going bankrupt. Twice. He has, well had, his own casino, his own reality TV show, and his own line of hair-care products. (Although that last venture isn't doing so well.) But it's still not enough. He has to do lecture tours, write books, and practice saying, "You're fired!" over and over. He is clearly not happy with his accomplishments or with himself. If he was, he wouldn't have to host a mindless TV show where he makes his guests cry.

Let's face it, if you had more money than France and were truly happy and satisfied, you'd build a nice house and retire. You'd do things



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you enjoyed and be oblivious to what the rest of the world thought. You'd surround yourself with the beautiful people you liked and might even just wear a bathrobe most of the time. Gee, that describes Hugh Hefner. On the other hand, now that I think about it, it also describes Michael Jackson. Well, never mind.

Anyway, the real point is that this innate dissatisfaction and unhappiness is a distinctly human trait. You never see mice or rats creating a reality TV show (although occasionally, they are unwilling and unpaid participants). Mice never trade their hard-earned mouse food for pills to reduce wrinkles or to enhance their love lives. However, it should be pointed out that mice do occasionally hoard food. But that makes sense when you swipe dry food from the cat's bowl. I mean, you wouldn't just sit around the bowl munching kibbles and watching *The Apprentice*. Otherwise, you'd be the TV dinner. Instead, you take it into the corner of the closet and eat it there. Any extra (and I'm not making this up), you stuff into the toe of the unused sneaker for later consumption during commercials.

LEARNING BY ASSOCIATION

All living things can learn by association. Quite simply, this is another name for cause and effect. But, since psychologists don't read physics texts, they made up their own name for it. The classic example of associative learning is Pavlov's dogs, which he trained to salivate at the sound of a bell. He did this by ringing a bell just before dinner. Of course, his work was based on the TV show *Wagon Train*, where the cook, Wishbone, would strike (de-press?) a large metal triangle and shout, "Come and get it!" A more up-to-date example of this behavior can be seen when Homer Simpson hears the word "donuts."

Of course, associative learning is not limited to eating and drooling. It is often the case where we associate one idea with another. Marketing people have been doing this forever. They always show their product (for example, laundry detergent) with a sexy person. In this way, you will associate their product with sex. So, the next time you are kissing a pretty girl you will have the irresistible urge to wash clothes.

Association can also couple unrelated items, so that the items can be confused with each other, like politician and weasel. Normally, there would never be any confusion because there is nothing similar between a politician and a weasel. (Except that they both have two ears, two eyes, and a large bushy tail.) But, if I say, "Politician ... Weasel ... Politician ... Weasel" enough times, you will eventually come to think of them together, or a "Poli-Weasel." (This should not be confused with a "Poli-Wog," which is what you get when you associate a politician and a hedgehog.) Naturally, this is totally unfair to the weasel, which has worked hard for his reputation and objects to the association. But, since weasels don't speak, their complaints

go unheard. Isn't it interesting, though, that no politician has complained?

CONCLUSION

It is clear that human behavior is, quite literally, anything you want it to be. You can behave like you mother says, or not. You can be part of a social group or be voted off the island for picking your nose and not sharing. Studying how humans behave is really a topic best left to the professionals. You should never do it at home.

Lastly, I want to respond to a sharp-eyed reader from McMurdo, Antarctica, who pointed out that if you forgot your keys, you could always have someone else drive you home. ■

P.S. Will someone tell Dave Barry to get back to work?

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>> WHAT A MESH!

I just found the article in your October magazine by Louis Frenzel about Wireless Mesh Networks. What a perfectly timed article! A friend and I were just discussing how to build a monitoring system for cranberry bogs. The temperature regulation is very important for cranberry plants. We thought it would be great to be able to build a floating monitor that would be deployable to multiple monitoring locations within the bog. The two

pieces of data we needed were temperature and location of the sensor. With a wireless mesh network, that would be very easy to do! Thanks for the great magazine and articles each month!

Dan Hoyer
Appleton Wi

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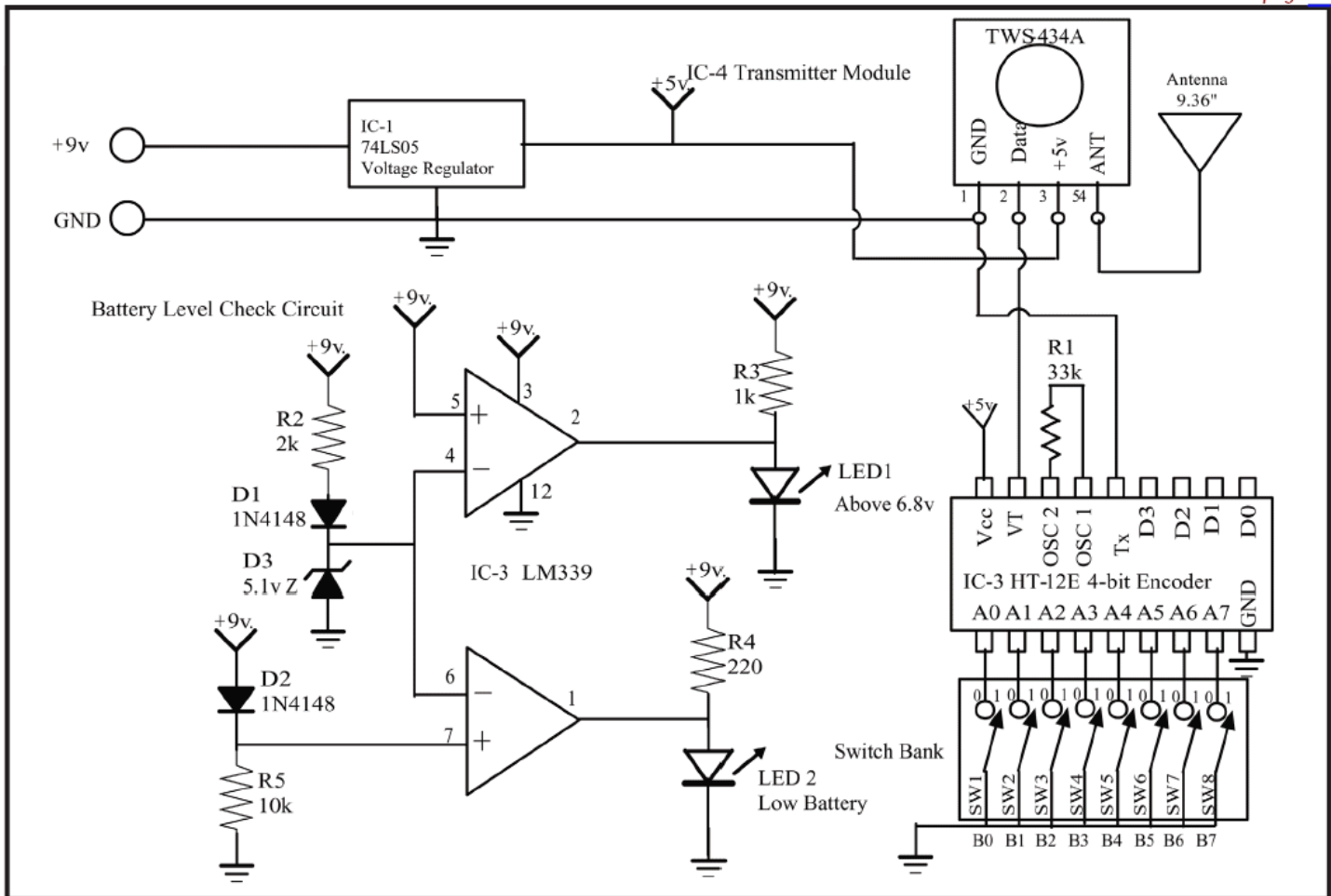
I just received my copy of the Oct. *Nuts &*

Volts and noticed a problem in my article.

Problem #1: Figure 4 (Transmitter schematic) is incorrectly showing the receiver schematic. This is going to cause some reader confusion. Shown here is the actual transmitter schematic.

Problem #2: Figure 6 states that the

Continued on page 78



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MAGNETIC MICROCHIPS REPLACE ELECTRONIC SEMICONDUCTOR

The combined efforts of researchers from Durham University, Imperial College, London, and the University of Sheffield have successfully created a computer by using magnetic microchips rather than semiconductor electronics. Till now, the basic computer is usually made by using semiconductor electronics. This development could offer a potentially economical and simpler way of computing for the future, which could also be put to new and useful purposes.

In 2002 at Durham, the researchers managed to create a basic computer operation or 'logic gate' using a magnetic microchip. Since 2002, the team has created a number of further 'logic gates' and created interconnecting structures using magnetic 'nanowires,' which can now reproduce the logic functions of a conventional computer empowered by semiconductor electronics.

Dr Del Atkinson of Durham University comments on this success: "This new technology offers a number of advantages over conventional computers. Electronic microchips generate a lot of heat, which creates the need for fans in PC units, whereas these magnetic microchips do not generate this heat. The magnetic microchips that have been created are also simpler and potentially cheaper to produce than the electronic chips. They are economical insofar as

they use simple metal layers.

This would also imply that the computers being economical could become more disposable. "This means that they could be used for cheap and therefore disposable simple computers in the future.," Dr. Atkinson further commented: "These developments are important and exciting and while there is still some way to go, the potential is there to create a whole new technology based on magnetism rather than electricity."

This use of magnetism, rather than that of electricity has potential of being utilized in other areas. The team is working in the rapidly growing field of nanotechnology, harnessing the magnetic properties of electrons, rather than their electrical charge on which conventional electronics is based. Nanotechnology involves working with materials at an extremely microscopic level. A nanometer is one thousand millionth of a meter — about the width of five atoms. Harnessing the capability of magnetic properties of electrons could mean a change in the field of electronics.



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GOOGLE PLANS OFFICES, PARTNERSHIP WITH NASA

Google, Inc., has confirmed that it will build up to 1 million square feet of offices at NASA Ames Research Center and collaborate with the space agency on research surrounding topics such as supercomputing that could benefit everything from moon launches to online searches.

The partnership is intended to blend the expertise and huge resources of one of the leading Internet companies with an army of scientists focused on the stratosphere and beyond.

"Google and NASA share a common desire to bring the universe of information to people around the world," said Eric Schmidt, the company's chief executive officer. "Imagine having a wide selection of images from the Apollo space mission at your fingertips whenever you want it."

The partnership, announced at a recent press conference at the NASA facility, will bring a marquee tenant to the Ames Research Center, located at Moffett Field, a former military airfield near Mountain View that has been struggling to find a new purpose since the military pulled out in the 1990s.

For Google, the new partnership comes at a time when the Internet search engine is expanding by leaps and bounds, hiring on average 10 people per day. Experts say the company, which now employs more than 4,000 people, has ambitions beyond Internet search and could give Microsoft Corp. a run for its money in desktop consumer computing.

In addition to supercomputing, the research and development between Google and NASA will involve biotechnology, information technology, and nanotechnology — the development of extremely small devices.

Google stands to gain from learning about NASA's supercomputers, which could come in handy as the Mountain View search engine compiles even bigger indexes of information and video. NASA leaders cited the benefits of getting access to Google's search expertise to pick out nuggets of information from the volumes of data streaming back from satellites and human space launches. ■

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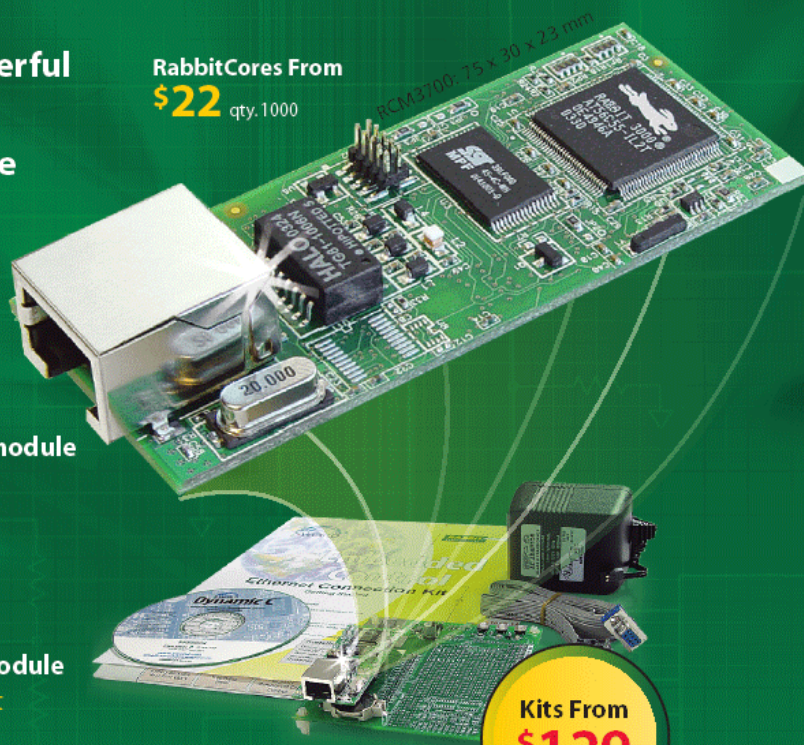
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>>>>NEW PIC24 AND dsPIC33F FAMILIES PROVIDE MORE PERFORMANCE, MEMORY & PERIPHERALS

Microchip Technology, Inc., a leading provider of microcontroller and analog semiconductors, has announced its first 16-bit microcontroller (MCU) family — the PIC24 — as well as its second 16-bit digital signal controller (DSC) family — the dsPIC33. The two families offer 49 new 16-bit devices for embedded system designers requiring increased performance, memory, and peripherals. Combined with the current 21 DSC products in the dsPIC30 family, this brings the total 16-bit devices offered by Microchip to 70.

Today's embedded system designers are faced with the challenges of delivering projects on schedule while hitting cost goals, responding to new customer and marketing requests, and providing significant product differentiation. Microchip's new 16-bit MCU and DSC families cost-effectively address these needs with up to 40 MIPS of performance — the industry's highest performance for 16-bit MCUs.



For eight-bit MCU users, the PIC24 and dsPIC33F families represent a cost-effective increase in performance, memory, and peripherals while maintaining the architectural efficiencies that embedded-control applications require, such as interrupt responsiveness, excellent bit manipulation, and industry-leading C code efficiency. To further enable fast and efficient development cycles, the new 16-bit families continue Microchip's seamless migration path from Mid-Range eight-bit MCUs to the new PIC24 and dsPIC33 families in terms of nomenclature, pin, and peripheral compatibility. Additionally, engineers can lower their tool investments and learning curves through Microchip's universal MPLAB® Integrated Development Environment (IDE) platform, which works across Microchip's more than 350 eight-bit and 16-bit device offerings.

"Providing cost-effective, compatible product families to enable our customers' success has always been the core of Microchip's strategy. Today, we are adding 49 PIC24 MCUs and dsPIC33F DSCs to our 16-bit product line," said Ganesh Moorthy, vice president of Microchip's Advanced Microcontroller and Memory Division. "These products provide our large eight-bit customer base with effective migration paths as their design requirements grow, as well as provide competitive alternatives to new customers who are looking for 16-bit device suppliers with a proven track record of innovation, a broad portfolio of products that are easy to use, and outstanding development tools and support to ensure their success."

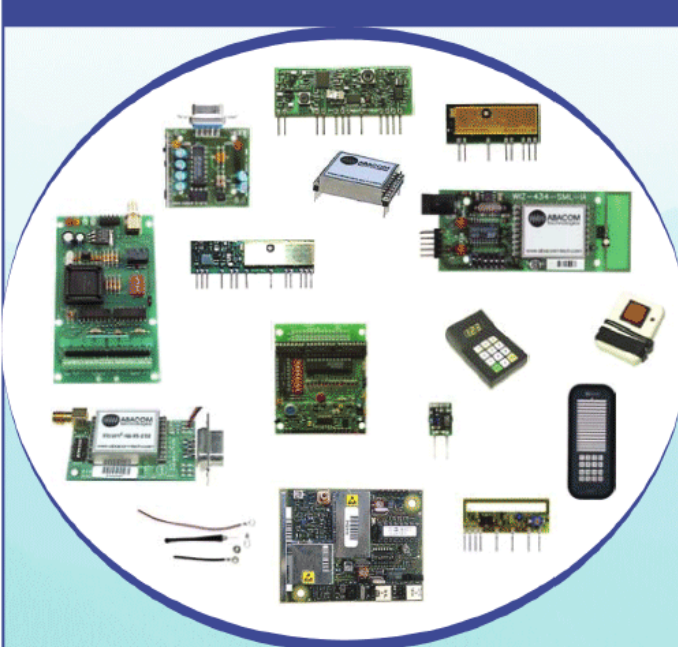
"With their dsPIC® DSCs and PIC24 MCUs, Microchip is the only company on the planet with truly unified DSP and MCU product lines," said Will Strauss, president of Forward Concepts. "The dsPIC33 family gives MCU people an easy migration path to DSP performance."

Development Tools and Availability

In addition to being compatible with the MPLAB IDE, the PIC24 and dsPIC33F families are supported by existing Microchip development tools, such as the MPLAB C30 C compiler, emulation, debugging, and the MPLAB PM3 universal device programmer. Microchip also created the Explorer 16 Development board in support of all 16-bit controllers. The Explorer 16 (part # DM240001) is expected to be available this November.

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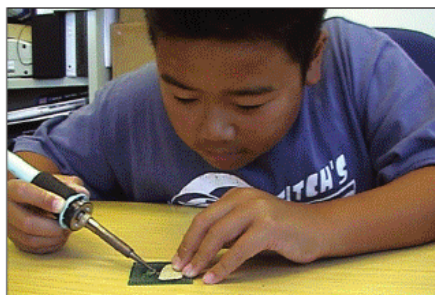
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>>>>WITH SCHMARTBOARDJEZ, a 10-year-old can now do what 99% of electrical engineers could not



SchmartBoard, a company that develops products for prototyping electronic circuits, unveiled a new line of prototype boards called SchmartBoardJez. The new product line makes it possible for virtually anyone to hand solder integrated circuits (ICs), even BGA (Ball Grid Array). "The design of this system is brilliantly simple. If I can quickly and easily solder components, I'm convinced that electrical engineers will see a significant productivity boost from this approach," said Chris Shipley, executive producer of the DEMO conferences.

"Prototyping boards have existed for a long time, but as surface mount components have become smaller and smaller, these boards have not kept up with the technology and have not remained a practical tool for most applications. Because of this, engineers are forced to use custom PCBs and can spend large amounts of time and money on revision after revision of expensive custom PCBs before they finally have the circuit perfected. By making prototyping boards viable again, SchmartBoardJez will save companies a tremendous amount of time and money," said Andrew Young, SchmartBoard's CEO. In addition to this need for an easy prototyping tool, SchmartBoardJez can be used as the circuit board in mass-produced technologies.

In discussions with universities, SchmartBoard has found that hand soldering components is also a hindrance in teaching electrical engineering. Universities want to focus on teaching theory, not soldering skills. The ability for students to hand solder is a significant hurdle especially on "senior projects" in which students are expected to create a working circuit in order to graduate. SchmartBoard feels that students will develop an interest in electronics at an earlier age due to SchmartBoardJez technology.

For more information, contact:
SchmartBoardJez
www.schmartboard.com

>>DSP/FPGA- based Motion Controller

DynoMotion, Inc., introduces the KMotion motion control board, which combines a DSP, an FPGA, output stages with power amps, USB connectivity, and a PC-based development environment to create a versatile and programmable single-board motion control solution. Designed for up to four axes, the KMotion provides advanced control for torque, speed, and position appli-

cations for any mix of stepper, DC brushless, and DC brush motors. The integrated output stages allow ultra-smooth stepper operation and high-performance DC operation while reducing space, cabling, interface headaches, and board count. KMotion uses Flash memory to store and run multiple-thread compiled C-Code on a 600 MFLOP processor with native 64-bit floating-point support for stand-alone operation. A PC connected by USB can be used for control and monitoring.

The included PC-based integrated development environment combines config-

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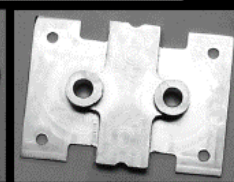
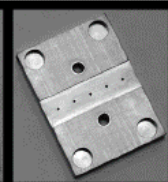
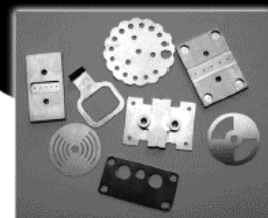
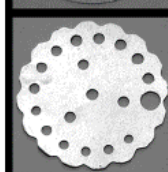
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uration, status, programming, and advanced diagnostic and tuning tools such as Bode plots and signal filtering. G-Code support allows coordinated moves between axes. Libraries for controlling the KMotion card via Visual C++ and Visual Basic are included, as well as a free C compiler. Thread-safe operation allows the IDE to be used in conjunction with a user application for control and debugging.

The KMotion has a lot of Input/Output into a small space measuring only 5 x 6.5 x 2.25 inches. Eight full bridges are controlled by 30 KHz 10 bit PWMs, and four 165 watt onboard current-limited power amps provide 3 A continuous current and 6 A peak current at 55 V. The KMotion utilizes 28 bi-directional I/O bits, shared between predefined limit switches and user-defined I/O. In addition, there are four channels of analog input (± 10 V) and 8 channels of analog output (4@ ± 10 V, 4@ 0 - 4 V).

The KMotion motion control board is being introduced at a price of \$899 in single quantities.

For more information, contact:
DynoMotion, Inc.
 Web: www.DynoMotion.com
 Email: sales@dynomotion.com

>> CUBLOC

A NEW CHIP THAT CUTS TIME & COST



CUBLOC from Comfile is a new type of chip for the automation world that can help cut development time and costs. Other advantages over other Basic interpreter chips include more I/Os, memory, faster "actual" processing time (based on "real" tests), and an advanced Basic language that allows you to program using sub functions. With Ladder Logic programming, PLC users can easily move to a newer level of programming. The user may choose to program in Basic and/or Ladder Logic Language. CUBLOC is for developers who want a more advanced Basic chip for stable, industrial mass-production.

CuTOUCH is a touch-screen version of CUBLOC. It embeds the CUBLOC module, touch-screen, 320x240 blue LCD screen, and a black case. The touch-screen can be controlled using commands such as "If Menucheck(0,X,Y) = 1 Then." The graphics can be easily imple-

mented using the graphical software, CuCANVAS, which creates the source code for you.

Both CUBLOC and CuTOUCH support floating-point math, native graphic LCD commands, and advanced Basic language similar to Visual Basic. All development software has free weekly updates.

CUBLOC and CuTOUCH can be connected to a Lantronix Xport or an Ethernet module to download and monitor through the Internet. With free Java source code, the user is free to develop remotely controlled devices through the Internet, as well.

The CB280 measures 1" x 1.38" x 0.43" w/ 80KB Flash memory for programming, eight ADCs, six PWMs, two RS232 ports, MODBUS support, and I2C. The CB280 starts at \$34 and CuTOUCH starts at \$359.

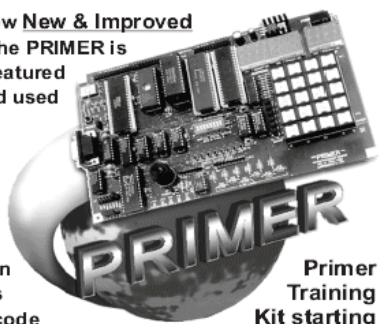
CuTOUCH measures 7.17" x 5.17" x 0.98" w/ 80KB Flash memory for programming, eight ADC, six PWMs, two RS232 ports, MODBUS support, and I2C. CuTOUCH comes with a 320x240 blue touch-screen.

For more information, contact:
COMFILE/Foster City, CA
 Tel: (888) 9CuBLOC
 Web: www.comfiletech.com

Continued on page 79

Microprocessor Hands-On Training

The PRIMER Trainer is now **New & Improved** and even easier to use. The PRIMER is a flexible instructional tool featured in Prentice Hall textbooks and used by colleges and universities around the world. Ruggedly designed to resist wear, the PRIMER supports several different programming languages. A comprehensive Self Instruction Manual and an Applications Manual provides lessons, theory, and sample code for a number of Hands-On lab projects.



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■ THIS MONTH'S PROJECTS

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■ LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

- Beginner Level
- Intermediate Level
- Advanced Level
- Professional Level

Last month, we looked at the hardware and software for our MP3 player project and presented the schematics.

This month, we'll talk about the actual construction, testing, operation, and possible modifications.

■ LEVEL RATING: ●●●●● (Professional)

BUILD AN MP3 PLAYER

PART 2 OF 2

Construction

Wherever possible, I've tried to use traditional thru hole parts in the design because the result is far easier for the home hobbyist to assemble. However, surface mount parts are a fact of life these days, and many modern parts, like the STA013 and CS4334, simply can't be found in any other form.

SMT Parts

You can purchase small "adapter" PC boards that will convert a surface mount part into thru hole; using these, you could assemble the entire circuit using point-to-point wiring techniques. A printed circuit board, however, will make the job much easier, faster, and less prone to error. A professional quality, double sided, plated hole, solder masked, and silk screened PC board is available from Spare Time Gizmos (refer to the parts list for ordering information).

Always begin construction by mounting the smallest surface mount parts first. This includes the STA013, the CS4334, OSC1, and the four SMT bypass capacitors. Once the other, taller parts are installed, you'll find it nearly impossible to work on these low profile parts, so use care and double-check your soldering under a magnifier before you proceed.

CompactFlash™ Socket

After mounting the SMT parts, the next step is to install and solder the CompactFlash™ socket. I can't say it too many times — once you install the other components on the PC board, you'll find it pretty much impossible to work on the CF socket, so it's critical to

get this right before proceeding.

Before you start, flip the CF socket over and look at the bottom. The CF socket has two little alignment nipples next to the screw holes which must be removed before it will fit the PC board. Use a utility knife or razor blade to trim off these little nibs. Be sure that the bottom surface of the socket is flat and smooth; otherwise some of the pins may not touch the PC board.

You can use #2 (English) machine screws or M1 (Metric) screws to mount the socket. M1 hardware is preferred because you can actually fit the hex nut down into the hexagonal cutouts on the top of the socket. If you use #2 hardware, you'll find the nuts are too large and you'll have to put the nuts on the bottom side of the PC board and the screw heads on the socket side.

Assemble all the screws, CF socket, and PC board, and tighten the screws finger tight. Use a magnifying lens and a good light to check the socket pins for the correct alignment with their pads — the socket pins and the pads are exactly the same width and all 50 of them should line up perfectly. Slide the socket around a little if necessary to fix the alignment and, as a last resort, use a small probe to bend one or more of the socket pins.

When you're happy with the pin alignment, tighten the screws and then go back and double-check to make sure it didn't slip. When all is well, solder the two metal feet at the front of the socket (one on the left and one on the right) first. Be careful not to melt the socket, but apply enough heat long enough for the solder to wick all the way under the socket and cover the pad completely. Between the soldered feet and the screws, the socket should now be firmly

locked into place.

The pads on the CF socket are 25 mils (0.025 inches) wide and have 25 mils between them. These pads are very thin and will separate easily from the PC board

if too much heat is used. To solder the pins, you'll need a temperature-controlled soldering iron with an ultra fine 0.015-inch diameter tip, some 0.010-inch silver solder, and some extra fine solder wick to fix the inevitable solder bridge.

With a little practice, it's not that difficult — just touch the tip of the iron to the pad on the PC board. Count to three while it heats up, and then touch the solder to the end of the CF socket pin. Try to avoid touching the iron tip with the solder if you can. If you do it right, the solder will only melt on the one pad/pin that's hot, and it'll wick up between the pin and the pad.

If you use too much solder and short to an adjacent pin (and you will at least once before you're done with all 50 pins — take my word for it!), use your extra-fine solder wick to remove the excess.

After you've gone to all the trouble of soldering on the CompactFlash socket, you really should invest 15 or 20 minutes in testing it before you proceed. *The CompactFlash socket is extremely difficult to work on after the other parts have been mounted*, and if there are any shorts or opens, you want to find out now, not later.

To check for opens, use a small sharp tool, such as a dental pick, to gently push on each and every pin. If the pin moves, then you need to fix it; a pin that's firmly soldered in place won't budge when you poke it.

Checking for shorts requires that you use an ohmmeter or continuity tester to check every pair of adjacent pins for a short. Notice that pins

■ **FIGURE 3 ELAS**

Once you get this far, take a break. The hard part is done, and the rest is an easy job of soldering a bunch of thru hole parts. Use care when installing the headers for J3 and J5 (the VFD and LCD connectors) — pin 1 of each connector is on opposite ends; this was done to improve the PCB layout.

Note that JP1 is just a single pin; it's installed next to JP2 and shares one of its pins. Be sure to solder the top of the CPU crystal to its ground plane for mechanical stability and so it's electrically bonded to ground.

Finally, remember that the VR2 will require a heatsink if it's used to power an external vacuum fluorescent display.

You'll need to make up a power cable to connect to J1 (remember that the center pin is positive) and a standard audio mini-plug cable for J2. There is no amplifier in the MP3 player, so you'll need to connect J2 to a set of powered speakers or an external amplifier.

You'll need a 14 conductor cable with 0.1-inch IDC headers to connect J3 to your LCD display, or a 16-pin cable to connect J5 to your vacuum fluorescent display. Remember that the VFD display pinouts aren't always standard; be sure to double-check yours against the MP3 player schematic. If your VFD does have a different pinout, just make up a custom cable for it.

You'll need a six conductor cable to connect the rotary encoder, which is usually mounted on the front panel along with the display. And lastly, make up a cable to connect J7 to the serial port on your PC (either a DB9 or a DB25 connector). The serial port connection uses only three wires — RxD, TxD, and ground — be sure to remember to connect J7 pin 4 to pin 1 (ground) to enable programming mode.

Install the remaining two ICs (the DS275 and the P89C664) in their sockets, and set the jumpers for programming as shown in Figure 2.

Connect a voltmeter to the output (C15 side) of VR1 and, if you've got a spare meter, connect a milliammeter in series with the power supply. *Do not install a CompactFlash card, connect an LCD or VF display, or connect the*

The screenshot shows the Flash Magic application window. At the top is a menu bar with 'File', 'ISP', 'Options', 'Tools', and 'Help'. Below the menu bar are several numbered callouts (1-5) pointing to specific features:

- 1** Points to the configuration table on the left.
- 2** Points to the 'Erase blocks' list on the right.
- 3** Points to the 'Hex File:' field and the 'Browse...' button.
- 4** Points to the 'Verify after programming' section.
- 5** Points to the 'Start' button.

Configuration Table (Left):

COM Port	COM 4
Baud Rate	19200
Device	93C564
Oscillator Freq. (MHz)	18.432

Erase blocks (Right):

- Erase block 0 (0x0000-0x1FFF)
- Erase block 1 (0x2000-0x3FFF)
- Erase block 2 (0x4000-0x7FFF)
- Erase block 3 (0x8000-0xBFFF)
- Erase block 4 (0xC000-0xFFFF)** (highlighted)

Buttons and Fields:

- ☒ Erase all Flash+Security
- ☐ Erase blocks used by Hex File
- Hex File: D:\Bob\mp3\wav\player\LOAD.HEX
- Modified: Wednesday, July 13, 2005, 10:07:26 AM
- [more info](#)
-
- ☒ Verify after programming
- ☐ Fill unused Flash
- ☐ Generate checksums
- ☐ Execute
- ☐ Set Security Bit 1
- ☐ Set Security Bit 2
- ☐ Set Security Bit 3
- ☐ 6 cks/cycle
-

At the bottom right, there is a status bar showing the number '2'.



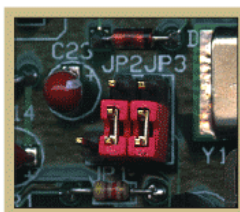
As a basic MP3 player, the hardware does pretty much everything you need, but there is plenty of room for adding features to the software. The user interface, especially, is ripe for enhancement. For example, the STA013 is capable of volume, balance, bass, and treble adjustments; all that's required is some firmware to set them.

Subdirectory support would be nice, as would support for M3U style playlists. And let's not forget scan forwards and backwards, shuffle play, and repeat play. Doing all this with a single knob and button for the user interface requires a little imagination, but it can be both very practical and even intuitive.

To embed this device, the rotary encoder could be replaced with up to three push button switches. The firmware would have to be modified to detect push button closures and do what's needed. This is how you'd make a doorbell or an alarm, for example.

For more sophisticated interfaces, the entire I2C bus is available from connector J8; with the appropriate firmware, this could be used to interface almost any peripheral.

And finally, the firmware can be modified to accept commands over the serial port; this way, you could use this player as a generic MP3 playback device controlled by another microprocessor. An MP3 player peripheral for your BASIC Stamp? *Maybe.*



■ **FIGURE 4.**
JUMPERS SET
FOR PLAYING

rotary encoder at this time. Apply 9 to 15 volts DC and check that the output of VR1

is 3.3 volts; if you have a milliammeter, the total current draw should be 100 to 150 mA. Next, check that the output of VR2 is 5 volts. If any of these readings are way off, pull the plug immediately and figure out where you went wrong.

Programming

Now you're ready to program the microprocessor. This can be done in-system using the serial port, a PC, and the FlashMagic programming software supplied to Philips by the Embedded Systems Academy. Download FlashMagic from the ESA website (see References sidebar) and follow the instructions supplied to install it on your PC.

Be sure that the board's jumpers are set for programming as shown in Figure 2 before you proceed. Connect the serial port cable and power up the MP3 player. Start FlashMagic and you'll find that ESA has done an excellent job of making it easy to use — just follow the numbers 1, 2, ... 5 like this:

STEP 1

- ☐ Select your COM port from the dropdown

REFERENCES

- ▶ CompactFlash Specification Revision 3.0, www.compactflash.org/
- ▶ Programming the Compact Flash card or Memory Stick, www.compuphase.com/mbr_fat.htm
- ▶ Detailed Explanation of FAT Boot Sector, <http://support.microsoft.com/kb/q140418/>
- ▶ How to Control a HD44780 Based LCD, <http://home.iae.nl/users/pouwheha/lcd/lcd.shtml>
- ▶ How to Use the STA013 MP3 Decoder Chip, www.pjrc.com/tech/mp3/sta013.html
- ▶ Bit Banging I2C Interfaces, www.keil.com/i2c/bitbang.htm
- ▶ STA013 MPEG 2.5 Layer III Decoder, STA013 Application Note AN1090, www.st.com/stonline/books/ascii/docs/6526.htm
- ▶ Cirrus Logic CS4334 Data Sheet, www.cirrus.com/en/products/pro/detail/P29.html
- ▶ P89C664 80C51 8-bit Flash microcontroller, www.semiconductors.philips.com/pip/P89C668.html
- ▶ In-application Programming of the 89C66x Microcontrollers, www.semiconductors.philips.com/acrobat_download/applicationnotes/AN461_7.pdf

list box.

- ☐ Set the baud rate to 19,200.
- ☐ Select the microcontroller type — either 89C664 or 89C668 — depending on which you used.
- ☐ Enter 18.432 for the crystal frequency. Remember that this refers to the CPU crystal — not the STA013 oscillator!

STEP 2

- ☐ Check the "Erase all Flash+Security" box. All other options will be grayed out when you do.

STEP 3

- ☐ Click the BROWSE button and open the firmware file.

STEP 4

- ☐ Check the "Verify after Programming" box. All other options should be unchecked.

STEP 5

- ☐ Click the START button!

Figure 3 shows an image of the FlashMagic screen after all the correct options have been selected. Erasing the flash, downloading the firmware, and verifying it takes a minute or so; if all goes well, then you're ready to proceed to the next step.

One last point — notice that the firmware is different for LCD and VFD displays; be sure you load the correct firm-ware for the display you're using. Loading the wrong firmware will usually cause the POST to fail with code 5 (display failure).

POST

Now remove the power and connect the display and rotary encoder, but don't install a Flash card just yet. Set the jumpers for playback as shown in Figure 4. Hold your breath and apply power once again. If the programming worked, the firmware will execute the power on self test and then display the copyright notice.

If you don't see the copyright

► TABLE 1: POST CODES

Flashes	Failure
1	CPU checksum failure
2	Flash (ROM) checksum failure
3	Internal SRAM failure
4	STA013 failure
5	LCD/VFD failure
6	Encoder/Switch failure
7	CF card failure

notice, the power on self test has probably detected an error. The POST firmware signals an error by flashing LED2 with a series of short flashes, a long pause, and then repeats. Count the flashes and check Table 1 to determine the failure.

Playing MP3s

Finally, we're ready to listen to some music! Take your CompactFlash card, format it, and copy some MP3 files to the root directory. *Remember that the firmware can only access FAT16 file systems and it can only play files in the root directory.* Recent versions of Windows, especially Windows XP, default to FAT32 format and you must explicitly pick "FAT" when formatting to get FAT16.

The current firmware is very simple-minded; it does not support play lists, and it only looks for MP3 files in the root directory. All non-MP3 files and subdirectories are ignored. Consider this an opportunity — there's plenty of room left in the Flash, and all it needs is a little programming to make it smarter!

Turn off the power again and plug in the Flash card and connect an amplifier. Be sure that you've set the jumpers as shown in Figure 4. *You must remove power before installing the CF card.* Yes, the CompactFlash standard allows "hot swapping," but not with TrueIDE mode. No harm will be done if you forget and change the CF card with the power applied, but the firmware probably won't be able to read the new card until you power cycle it.

Turn the power on one last time and the display will show the copyright for a few seconds, and then it will begin playing the first song. While playing, the display shows the file name, song title, and artist name from the ID3 tag, if any, on the first three lines. The fourth line will show the running time, bit rate, and sample frequency for the song playing. If it passes the POST but doesn't play, then the firmware either doesn't recognize your Flash card or it can't find any MP3 files there.

While playing, turning the knob will skip from one song to the next or previous one, and pushing the knob button will alternately pause and resume playing. That's the extent of the current user interface at the moment. Remember, I said that the firmware was very simple minded! The hardware is capable of much more; adding additional functions is simply a matter of programming. ■

See next page for Parts List.

ACKNOWLEDGEMENTS

■ The analog output circuit for the CS4334 is straight out of the Cirrus Logic data sheet and the circuit for the STA013 is mostly borrowed from the ST datasheet.

■ There are many, many, many MP3 player projects on the Internet and, although this design is unique, I've certainly borrowed ideas here and there. Some of the better sites are listed in the References list included in this article.

PIC Programming Made Easy! Proton+ PICBASIC Development Suite



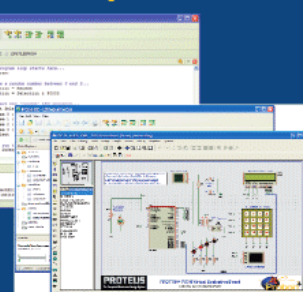
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PARTS LIST

CAPACITORS

(All capacitors are 50W VDC unless specified)

- C1, C2 - 22pF monolithic
- C3, C26, C27 - 0.1µF monolithic
- C4 - 100µF 35V aluminum
- C5 - Unused
- C6 - 470pF monolithic
- C7 - 4.7nF (0.0047µF) mylar
- C8, C9 - 3.3µF 6V tantalum
- C10, C14, C15, C23, C24, C25 - 10µF 6V tantalum
- C11, C16, C17, C18, C19 - 0.1µF 1206 SMT ceramic
- C12, C13 - 47pF monolithic
- C20, C21 - 3.3nF (0.0033µF) mylar

RESISTORS

(All resistors are 1/8W 5% carbon composition unless specified)

- R1, R3 - 4.7 ohms (not 4.7K ohms!)
- R2, R4, R18 - 10K
- R5 - 1K
- R6, R7 - 270K
- R8, R9 - 560 ohms
- R10, R11, R13, R14, R15, R16, R17 - 4.7K
- R12 - 270 ohms
- R19, R20 - 330 ohms
- RP1 - 10K 10 pin (One common pin) SIP
- RP2 - 4.7K 6 pin (One common pin) SIP
- TR1 - 5K trimmer

SEMICONDUCTORS

- D1 - 1N914 diode

- D2 - 1N4001 1A 50PIV diode
- D3 - 1N4749 24V 1W Zener diode
- LED1, LED2 - Right angle PCB mount LED (Dialight 555-2001 or Dialight 555-2301)
- OSC1 - 14.31818 MHz 3.3V SMD Oscillator (Citizen CMX-309)
- Q1, Q2 - 2N2222 plastic transistor TO-92
- U1 - P89C664 microprocessor PLCC44
- U2 - Dallas DS275 RS232 transceiver DIP8
- U3 - SGS-Thompson Microelectronics STA013
- MPEG 2.5 Layer III Decoder SO28
- U4 - Cirrus Logic CS4334 24 bit 96 kHz Stereo D/A Converter SOIC8
- VR1 - LP2950CZ-3.3 3.3V 100 mA regulator TO-92
- VR2 - 7805 5V 1A regulator TO-220

CONNECTORS

- J1 - Coaxial power connector (Cui Stack PJ-102AH)
- J2 - 3.5 mm stereo jack (Cui Stack SJ-3533N)
- J3 - 14 pin 0.1" shrouded header
- J4 - 2 pin header
- J5 - 16 pin 0.1" shrouded header
- J6 - 6 pin header
- J7 - 4 pin header
- J8 - Unused
- J9 - Type I CompactFlash connector, SMT right angle top mount (Molex/Waldom 53856-5010)

(* Note: J4, J6, and J7 may be any 0.1" header. I prefer the Amp MTA series or the Molex KK series, but many others will fit the PC board.)

MISCELLANEOUS

- L1 - 470 µH 100 mA RF choke
- PB1 - 6 mm PCB mount push button switch (Panasonic EVQ-PAD05R)
- Y1 - 18.432 MHz microprocessor crystal HC-49
- F1 - 1A slow blow pico fuse axial lead (Littelfuse 0473001)
- JP1 - 1 pin 0.1" square post header (jumper)
- JP2, JP3 - 3 pin 0.1" square post header (jumper)
- Encoder - 16 position optical rotary encoder (Grayhill 61C22-01-04-02)
- Display: Noritake ITRON CU20045SCPB-T28A 4x20 vacuum fluorescent display, or Optrex DMC40457 4x20 LCD display
- Printed Circuit Board

SUPPLIERS

- Embedded Systems Academy — www.esacademy.com/ — FlashMagic programming software
- Mouser — www.mouser.com — Resistors, capacitors, inductors, semiconductors, LEDs, connectors, other small parts
- Newark — www.newark.com — CS4334 and many other parts
- Dallas Semiconductor — www.dalsemi.com — DS275 chip
- PJRC — www.pjrc.com/store/ — STA013 and CS4334 chips
- Spare Time Gizmos — <http://mp3.SpareTimeGizmos.com> — Printed circuit board, CompactFlash connector

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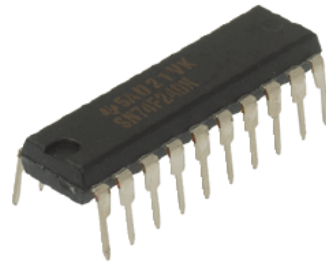
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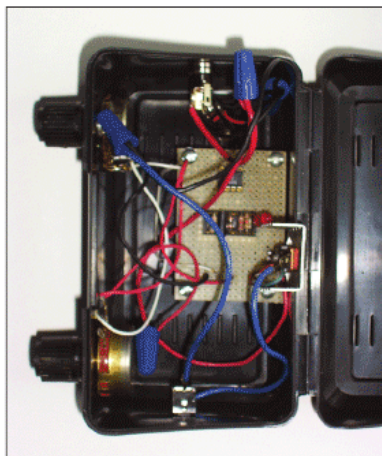
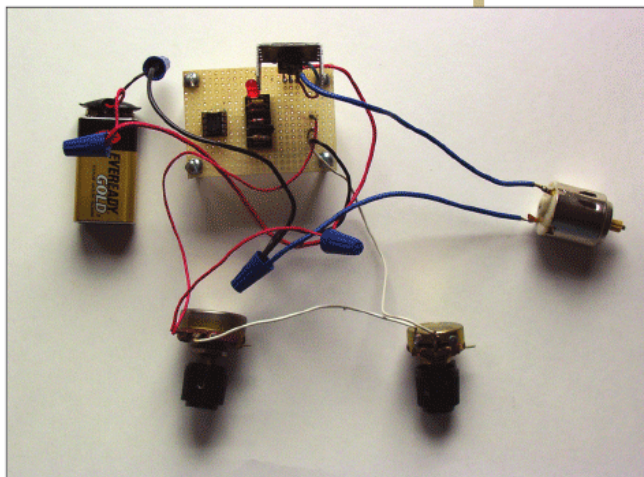
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SMALL DC MOTOR PWM SPEED CONTROLLER

There are numerous applications for motor speed controllers, ranging from train sets and radio-controlled cars, to the area of robotics. About a year ago I needed to control the speed of a small

12 volt DC motor attached to a peristaltic pump used for water sampling. A peristaltic pump is a type of suction pump that squeezes a piece of rubber tubing which, in turn, causes a vacuum. The challenge with these pumps is that they require quite a bit of torque to squeeze the tubing, and in my situation, they had to run from as little as

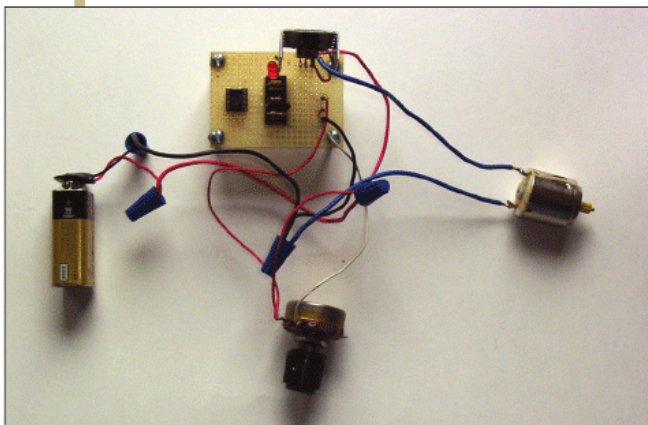
three revolutions per minute to full speed. In thinking about the problem, I knew that simple methods of motor speed control — such as using a potentiometer or a transistor as a variable resistor — were out of the question. Both methods have serious drawbacks. If you use a potentiometer, you quickly discover that it gets very hot, and that the only way to alleviate that is to exchange it for an expensive rheostat.

Using a transistor solves the expensive rheostat problem, but instead you end up using an awfully large heatsink to prevent the transistor from burning up. The other problem is that you lose torque at low motor speeds, since you are supplying very little voltage or current at these speeds.

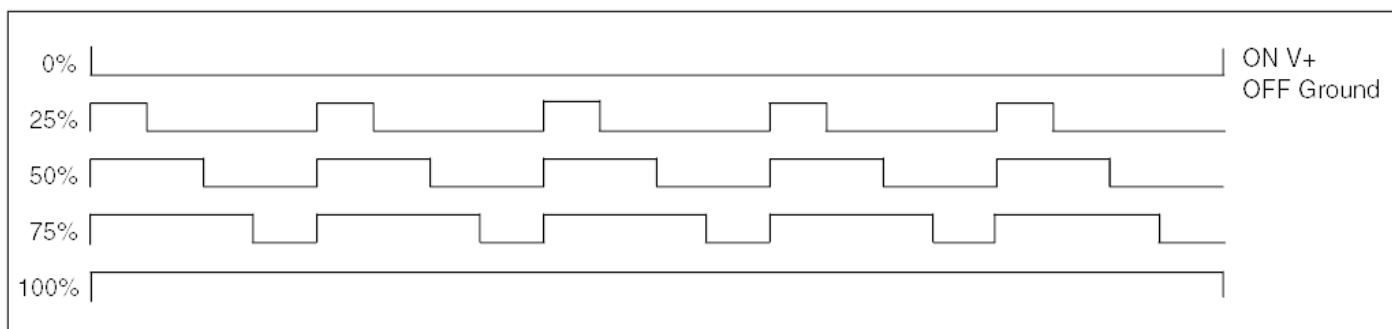
Dissipating most of the power in the form of heat across the pot or transistor can pose an even a bigger headache if the project is battery operated. To solve these problems, electrical engineers have come up with a technique called pulse width modulation, or PWM. The DC motor speed controller described in this article uses a modified form of PWM, a technique for which you will find numerous applications.

Circuit Description

The heart of the motor speed controller is the 555



■ SMALL DC MOTOR SPEED CONTROLLER CONSTRUCTED ON A SMALL PIECE OF PERFBOARD.



■ **FIGURE 1: PULSE WIDTH MODULATION DUTY CYCLE. NOTE THAT THE LENGTH OF ON PULSE TIME STAYS CONSTANT, WHILE OFF PULSES VARY.**

timer. By running in the astable mode and controlling the discharge time of capacitor C1, via potentiometer R1, you can generate a series of pulses in which the duration between pulses can be varied. Figure 1 shows a timing diagram from 0% duty cycle to 100%. As can be seen in the timing diagram, the width of the on pulses stays constant while the off pulses vary in length. At low motor speeds, the time between on pulses increases.

The advantage of this system is that the motor receives full current and voltage at low speed but for shorter periods of time. This makes it possible for the motor to maintain torque. It also decreases the amount of heat the transistor dissipates, since it acts like an on/off switch and not as a variable resistor. This makes it possible to use a smaller heatsink than the method described above. As you decrease the length of time between on pulses the faster the motor goes.

Construction

Any construction method — from making your own printed circuit board to point-to-point wiring — can be used. I used several construction techniques in my prototype circuit. Since I like wire wrapping, I used this technique to connect the smaller components to the 555 IC. The transistor was soldered to a couple of posts, and the connecting wires to the pot and the motor were wire nutted together. Wire nuts make great connectors when attaching several wires together.

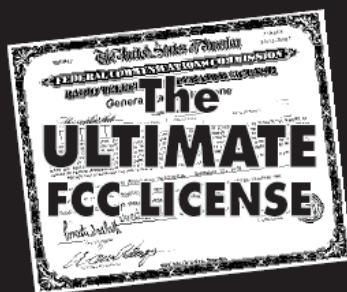
Just remember that nuts come in numerous sizes to accommodate different wire sizes. I used screws with nuts to provide legs for the project, which helped prevent the wire wrap socket from getting crushed.

The size of the heatsink will depend on the size of the motor. Small hobby motors may not require the transistor to be heat slaked at all, while larger motors will. I generally try to run the transistor as cool as possible. If it feels warm to the touch, heatsink it.

When performing this test, be careful not to burn your fingers. For most applications, only a small heatsink is necessary. Heatsinks can be purchased, made from a piece of metal, or can utilize the side of a metal enclosure.

Operation

The speed controller can be operated from 5 to 15 volts. To operate the unit, adjust the 100K pot to the proper speed or use the optional visual speed indicator LED (L2). The rate that the LED flashes gives you a good idea how fast the motor is running, especially at low speeds.



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PARTS LIST

Semiconductors

Q1 — TIP42 PNP Power transistor or equivalent

Integrated Circuit

IC1 555

Resistors

(All resistors are 5%, .25 watt units, unless otherwise stated.)

R2 — 6.8K ohm

R3 — 1K ohm

R4 — 1K ohm (Optional)

Potentiometer

R1 — 100K linear

Capacitors

C1 — 1uf Electrolytic capacitor, 35 working volts

C2 — .1 uF Ceramic disc capacitor, 50 working volts

Diode

DI — 1N914 Switching diode

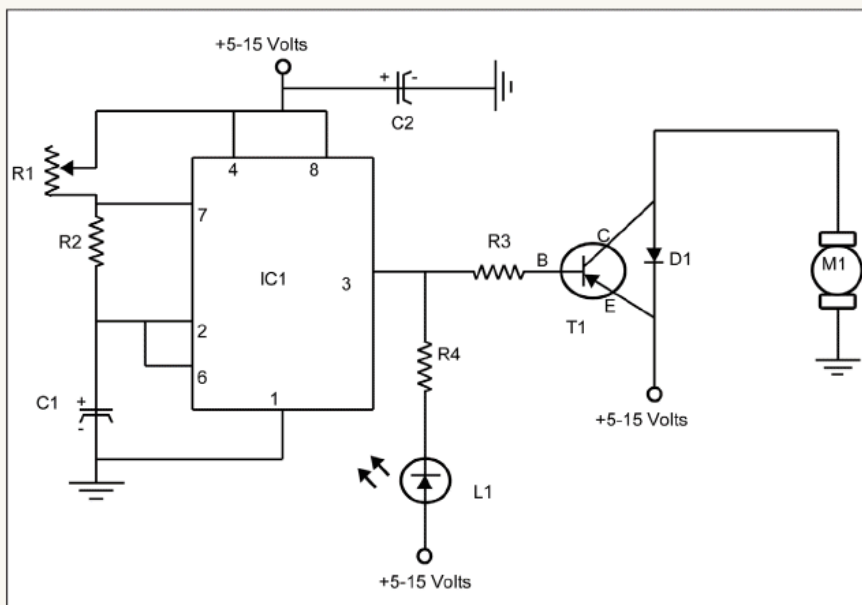
Light Emitting Diode

LI — Light emitting diode (Optional)

Additional Materials

Suitable heatsink

■ FIGURE 2: SCHEMATIC FOR SMALL DC MOTOR SPEED CONTROLLER. LIGHT EMITTING DIODE LI AND RESISTOR R4 ARE OPTIONAL, AND ARE ONLY USED FOR VISUAL INDICATION OF MOTOR SPEED.



Optimization

While the speed controller is optimized for 90% of the small motors on the market, there are a few changes that you might want to try. If you want extremely slow motor speed control in the neighborhood of a few revolutions per minute, you might want to put a 500K or 1MB pot in series with the 100K pot. The 500K/1MB pot can be used for low motor speed control and the 100K pot for high.

This method works extremely well. At these speeds, the motor shaft moves in well-defined increments.

Usually, this is not a problem, and in some circumstances it can even be an advantage. The motor moves at these speeds in much the same way a stepper motor moves — and in some cases could replace one. Increasing

or decreasing the value of R3 from 3.3K to 10K may also improve motor performance. Outside these ranges, the motor will either move erratically or stall. ■

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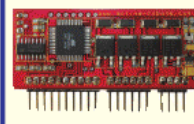
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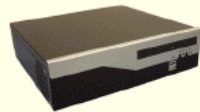
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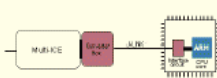
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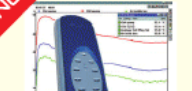
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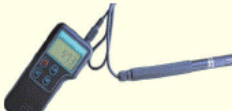
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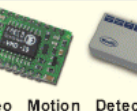
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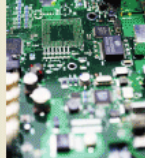
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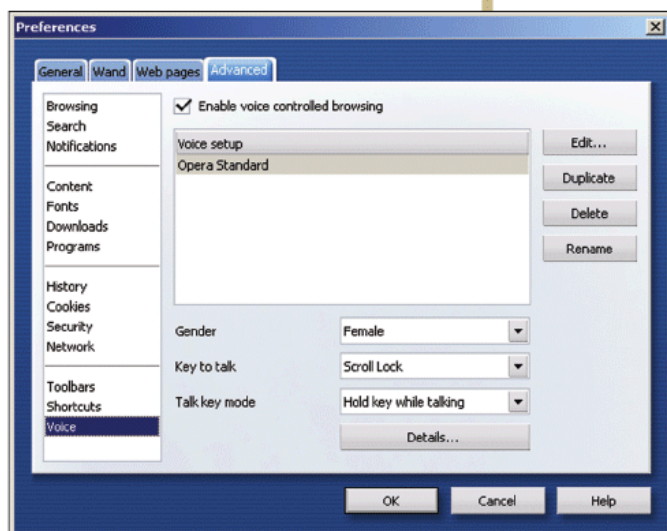
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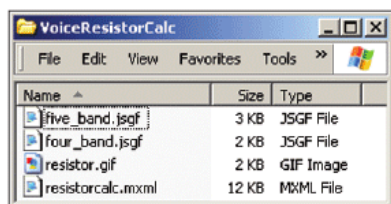


How to Create a Resistor Color Code Calculator

Using XHTML + Voice



■ FIGURE 1. ENABLING VOICE IN THE BROWSER PREFERENCES



■ FIGURE 2. PACKAGE CONTENTS

■ LEVEL RATING: ●●●● (Intermediate)

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Introduction

Years ago, I was involved in electronics both professionally — as a technician in a small electronics shop — and as a hobby. Over the years, focusing my time and energy on a career in computers put my tinkering with electronics on hold, but that recently changed when I rekindled my interest in working on electronics projects as a hobby.

Having completely forgotten the resistor color code (although I'm not positive that I had it memorized way back when), I found myself very slowly sorting through a pile of surplus resistors one night when I decided to create my own resistor color code calculator.

Now, I know there are a number of these already available on the Web, but I wanted to write one with a voice-enabled interface so

that I could just pick up a resistor out of the pile, speak the color codes to my computer, and have it speak the resistance value back to me.

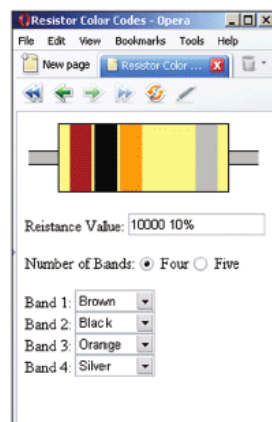
The technology I used to make this is called XHTML + Voice, or X+V for short. It allows you to create a Web-based application using XHTML and easily voice-enable it using a subset of VoiceXML.

Setting up Your PC for X+V

The first thing you need to do is to download a Web browser that can properly render X+V pages. The recently released Opera 8 is just such a browser. A free version is available from www.opera.com/download/. The only restriction with the free version is that it will display a banner ad at the top of the window until you pay the registration fee. Currently, X+V is only supported in the Windows version of their browser.

Once you have downloaded and installed Opera, you need to enable the voice option which, in turn, will download about 10.5 MB of additional libraries needed for voice recognition and text to speech (TTS). To enable voice, select Preferences from the Tools menu, click on the Advanced tab, and in the Voice panel select the checkbox "Enable voice controlled browsing." I also like to change the TTS voice from the Male default to Female, but that's a matter of choice.

You also need to make sure that you have a microphone or headset connected to your PC. Some PCs have microphones built in, but the audio quality is usually much better



■ FIGURE 3. THE MAIN X+V WEB PAGE

with a good noise-canceling headset or microphone. I have an omni-directional microphone that was made for dictation sitting on my desk next to my monitor, so that I don't have to mess around with putting on a headset every time I want to interact via voice with the computer.

Try it Out

First, let's download the application and try it out. I'll describe how it works later. You

can download the package from the *Nuts & Volts* website (www.nutsvolts.com). Unzipping the archive reveals four files:

The file `resistorcalc.mxml` is the main X+V file. It contains XHTML content to display the visual components of the resistor color code calculator, as well as the VoiceXML forms that are used to handle the voice dialogues. The two `.jsgf` files are the external grammars that define what you can

► FIGURE 4. STARTING A VOICE FORM WHEN THE PAGE LOADS

```
<body ev:event="load" ev:handler="#four_band_voice">
```

► FIGURE 5. STARTING A VOICE FORM WHEN THE NUMBER OF BANDS CHANGES

```
function numBandsChanged() {
    var e = document.createEvent( 'UIEvents' );
    e.initEvent( 'DOMActivate', 'true', 'true' );
    if (curNumBands == 4) {
        docEl( 'five_bands_span' ).style = "display:none";
        docEl( 'four_bands_span' ).style = "visibility:visible";
        docEl( 'four_band_voice' ).dispatchEvent( e );
    } else if (curNumBands == 5) {
        docEl( 'four_bands_span' ).style = "display:none";
        docEl( 'five_bands_span' ).style = "visibility:visible";
        docEl( 'five_band_voice' ).dispatchEvent( e );
    }
    calcResValue();
}
```

► FIGURE 6. THE FOUR BAND VOICE FORM

```
<vxml:form id="four_band_voice">
    <vxml:grammar src="four_band.jsgf"/>
    <vxml:field name="band_1_n"/> <!-- the numerical value -->
    <vxml:field name="band_1_c"/> <!-- the color name -->
    <vxml:field name="band_2_n"/>
    <vxml:field name="band_2_c"/>
    <vxml:field name="band_3_n"/>
    <vxml:field name="band_3_c"/>
    <vxml:field name="band_4_n" cond="false"/>
    <vxml:field name="band_4_c" cond="false"/>
    <vxml:filled mode="any">
        ...
    </vxml:filled>
</vxml:form>
```

► FIGURE 7. THE FOUR BAND GRAMMAR ROOT RULE

```
public <four_band_colors> =
    <band_1> { $.band_1_n = $band_1.n; $.band_1_c = $band_1.c; }
    <band_2> { $.band_2_n = $band_2.n; $.band_2_c = $band_2.c; }
    <band_3> { $.band_3_n = $band_3.n; $.band_3_c = $band_3.c; }
    [<band_4> { $.band_4_n = $band_4.n; $.band_4_c = $band_4.c; } ] ;
```

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FIGURE 8. THE GRAMMAR CHILD RULES

```
<numbers_0_to_9> =
  black { $.n = '0'; $.c = 'black'; } |
  brown { $.n = '1'; $.c = 'brown'; } |
  red { $.n = '2'; $.c = 'red'; } |
  orange { $.n = '3'; $.c = 'orange'; } |
  yellow { $.n = '4'; $.c = 'yellow'; } |
  green { $.n = '5'; $.c = 'green'; } |
  blue { $.n = '6'; $.c = 'blue'; } |
  violet { $.n = '7'; $.c = 'violet'; } |
  grey { $.n = '8'; $.c = 'grey'; } |
  white { $.n = '9'; $.c = 'white'; } ;

<multipliers> =
  black { $.n = '1'; $.c = 'black'; } |
  brown { $.n = '10'; $.c = 'brown'; } |
  red { $.n = '100'; $.c = 'red'; } |
  orange { $.n = '1000'; $.c = 'orange'; } |
  yellow { $.n = '10000'; $.c = 'yellow'; } |
  green { $.n = '100000'; $.c = 'green'; } |
  blue { $.n = '1000000'; $.c = 'blue'; } |
  gold { $.n = '0.1'; $.c = 'gold'; } |
  silver { $.n = '0.01'; $.c = 'silver'; } ;

<tolerance> =
  gold { $.n = '5%'; $.c = 'gold'; } |
  silver { $.n = '10%'; $.c = 'silver'; } |
  none { $.n = '20%'; $.c = 'none'; } ;
```

say and how the results get back into the VoiceXML form. They could have been defined as inline text within the X+V file, but I chose to make them external files. The last file, resistor.gif, is simply a background graphic of a resistor without any color bands. The bands will be dynamically drawn onto the picture as the color values are selected.

So, let's give it a try. Launch the Opera browser and either drag and drop resistorcodes.xml onto the main window or select Open from the File menu and navigate to where you saved it. You should see the main page shown in Figure 3. If you do not see the microphone icon on your toolbar, you can add it by right clicking on the toolbar and selecting "Customize...." The microphone icon is in the Buttons tab under the Browser panel. You can just drag and drop it anywhere on the toolbar you like.

Click on either the Four or Five radio button to select the number of bands to calculate and select the colors for each band from the dropdown menus. You should see the colors on the resistor change and the Resistance Value text field update whenever you make a change.

Now let's see if we can give the voice interface a try. In order for the browser to recognize your voice commands, you have to tell it when to start listening. By default, Opera uses the scroll lock key as the Push to Talk (PTT) key. Select either the Four or Five band radio button, and then press and hold the PTT key while you say the colors of the bands. When you are done, release the PTT key and you should hear the results read back to you using TTS. You will hear a quick "ding" before you should start speaking and after you release the PTT key.

Try both the Four and Five band options a few times. Speaking the

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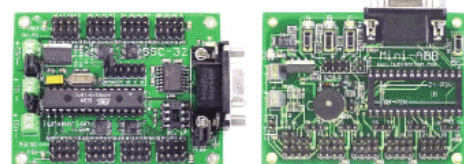


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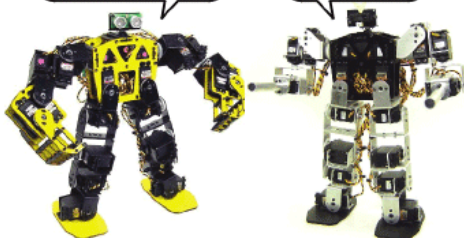


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last band is optional. So, if you have the Four band selected but speak only three colors, the TTS will respond with only the value of the resistor — not the tolerance. If you speak the last band, it will also inform you of the tolerance percentage.

How it Works

X+V works by combining three XML based standards: XHTML, a subset of VoiceXML, and XML Events. The XHTML markup handles the visual part of the application. VoiceXML is a very powerful language for creating voice dialogues. XML Events ties the two together, allowing user actions on the XHTML to start and stop VoiceXML forms and handle events generated from them.

The visual piece of this application consists of a .gif image of a resistor, a text field to display the results of the calculation, two radio buttons to select four or five bands, and a set of select elements to set the color of each band. A couple of the select elements are dynamically hidden or displayed, depending on whether four or five

bands are selected.

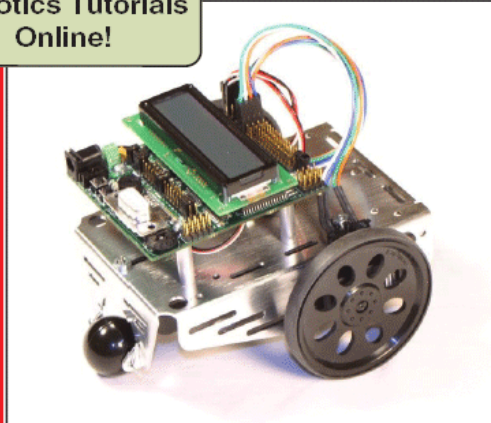
When the color of a band is changed, the new value of the resistor is calculated through the JavaScript function `calcResValue()`. When the number of bands is changed, the `numBandsChanged()` JavaScript function is called, which dynamically displays the correct number of color dropdown menus.

FIGURE 9. THE <FILLED> ELEMENT

```
<vxml:filled mode="any">
  <vxml:var name="result" expr="( (parseInt (band_1_n) * 10) +
  parseInt (band_2_n)) * parseFloat (band_3_n)"/>
  <vxml:assign name="docEl('res_val_html').value" expr="result"/>
  <vxml:assign name="docEl('sel_band1').value" expr="band_1_n"/>
  <vxml:assign name="docEl('sel_band2').value" expr="band_2_n"/>
  <vxml:assign name="docEl('sel4_band3').value" expr="band_3_n"/>
  Colors
  <vxml:value expr="band_1_c"/>
  <vxml:value expr="band_2_c"/>
  <vxml:value expr="band_3_c"/>
  <vxml:if cond="band_4_c != undefined">
    <vxml:value expr="band_4_c"/>
  </vxml:if>
  Have a value of <vxml:value expr="result"/> ohms.
  <vxml:value expr="syncBandColors()" />
  <vxml:clear/>
</vxml:filled>
```

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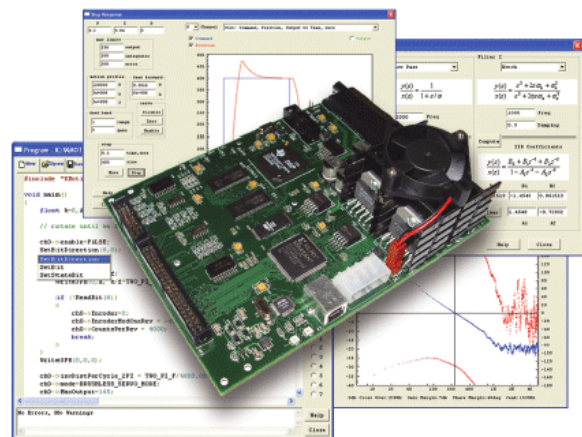


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There are two voice forms embedded in the head section of the XHTML. By default, the four band value is selected and its corresponding voice form is started when the document is loaded. This is accomplished by using an XML Events handler on the body tag.

The JavaScript function that hides and displays the correct visual elements when the user changes between four and five bands also starts the appropriate voice form using DOM Level 2 events.

Similar to HTML, VoiceXML has a form element that can contain multiple field elements. The values for these fields are filled in not by typing, like in HTML, but by speaking. A grammar is used to define what the user can say and how the results are assigned to the fields in the voice form.

The voice forms in this application are fairly simple. They contain two fields for each possible band on the resistor. One field is designed to hold the numerical value, while the other holds the name of the color as a text string. The field representing the last

ADDITIONAL RESOURCES

Additional information can be found at these websites:

■ Opera Browser's Voice Quick Start-up Guide
www.opera.com/voice/

■ IBM Multimodal
www.ibm.com/pvc/multimodal/

■ X+V 1.2 Specification
www.voicexml.org/specs/multimodal/x+v/12/

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band of the resistor is set as optional.

There is one form level grammar defined as an external JSGF (Java Speech Grammar Format) file. The grammar file defines a set of rules, which establish what the user can say and how the utterance is translated back into the voice form. This grammar has one main public rule, which is comprised of four child rules, one for each resistor band. The fourth one is optional.

The individual bands are further broken down into rules that define which colors can be spoken for each position. Inside of the curly braces to the right of each color is something called semantic interpretation. It is essentially JavaScript code that is executed when the word on the right is matched. For each band on the resistor, I use semantic interpretation to store both the numerical value of the color in that position and the name of the color itself. These values map to two fields in the voice form.

Getting back to the voice form, once an

Adding voice to an interface can greatly improve the ease of use of the application by another mode of input and output.



utterance is matched against the grammar, the values of the fields in the voice form are set to the values from the code executed in the semantic interpretation and the <filled> section of the voice form is executed. This is where you can do any processing required after the recognition takes place. For this application, this is where I calculate the resistor's value, construct the text to speech output phrase, and update the visual elements on the page.

A combination of the <assign> and <value> tags are used to assign values directly into the HTML fields and call a JavaScript

function in the page that draws the colors of the resistor.

Conclusion

The combination of many Web technologies and standards allows authors to create useful applications with very nice user interfaces. Adding voice to that interface can greatly improve the ease of use of the application by another mode of input and output. What would normally require selecting a value from four or five different controls can now be accomplished with a single spoken utterance. Plus, you don't need to take your eyes off of your work, as the results can be spoken back to you through text to speech. ■

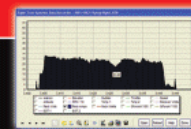
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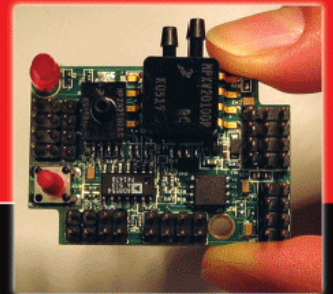
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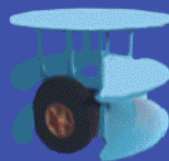
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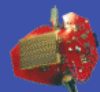
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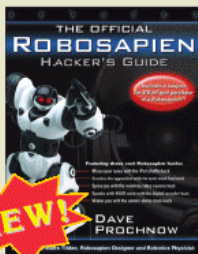
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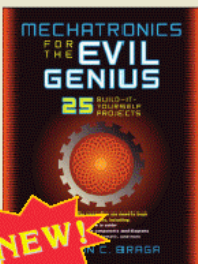
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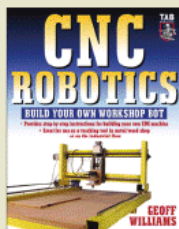
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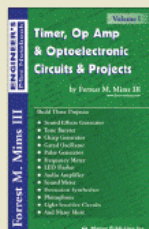
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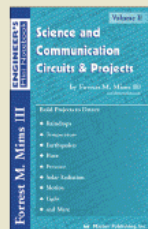


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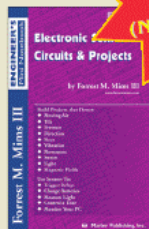
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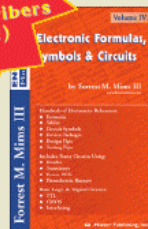
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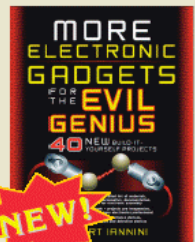
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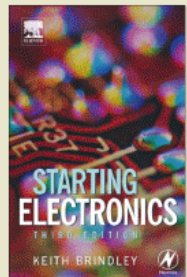
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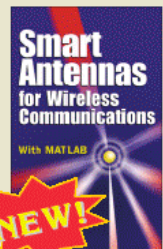
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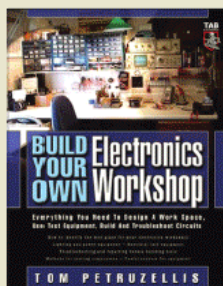


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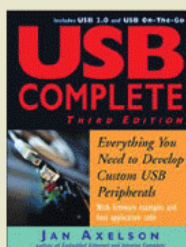


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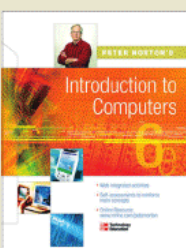
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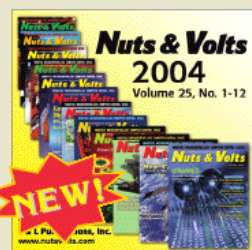
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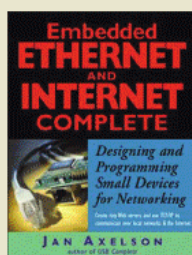
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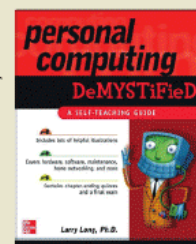


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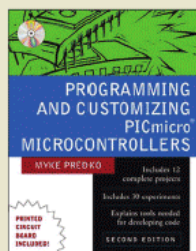


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by Myke Predko

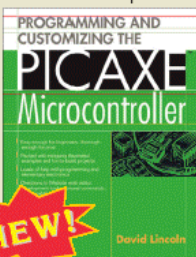
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This article will be limited to analog filters built with discrete components. Filters can also be made using digital signal processing (DSP) and analog distributed components (transmission lines and resonant cavities).

It is necessary to have an understanding of these terms:

REACTANCE ■ The resistance (impedance) to AC current flow caused by an inductor or capacitor. It is measured in Ohms. The reactance of an inductor increases with frequency; the reactance of a capacitor decreases with frequency. The symbol for inductive reactance is X_L ; the symbol for capacitive reactance is X_C .

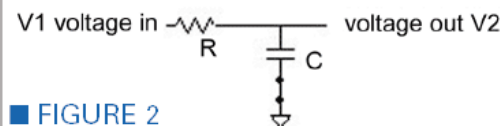
DECIBEL ■ This is merely the logarithmic compression of data, abbreviated dB. For voltage, the equation is $20 \cdot \log(V1/V2)$. For power, the equation is $10 \cdot \log(P1/P2)$. The advantage of using dB is that a plot of attenuation versus log frequency will, for the most part, be a straight line. -6 dB represents an attenuation of 0.5, if you work it out, and +6 dB represents a gain of 2. Every -6 dB is 1/2, so -36 dB is $.5 \cdot .5 \cdot .5 \cdot .5 \cdot .5 \cdot .5 = 0.034$ and -72 dB is $.034 \cdot .034 = .0012$.

The ideal low pass filter will pass all signals below a given frequency (the cutoff frequency) and not pass any signals above the cutoff frequency. A high pass filter does the opposite. The ideal is not achievable, but complex filters can come close.

A problem arises when the phase response of the filter is considered. Complex waveforms (pulses) can be considered as composed of many harmonics. If the phase of the component waves is changed relative to one another, the pulse form is changed. In applications where pulse shape is important (television), phase response is an important parameter. The best results are obtained when the phase varies linearly with frequency. Linear phase filters is a subject by itself and is not covered here. As you might expect, sharp cutoff filters have more nonlinearity in the phase response than filters with a more gradual attenuation versus frequency.

The simplest low pass filter consists of a reactive element and a resistor. The reactive element can be an inductor (Figure 1):

Or a capacitor (Figure 2):

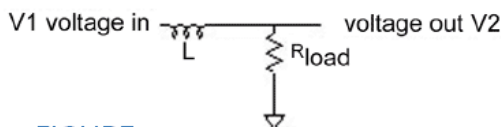


■ FIGURE 2

Figure 1 is an L-R circuit to be analyzed, first is a SPICE transient analysis using a sine wave source of 159 kHz. The reactance of the 1 mH inductor is equal to the 1K ohm resistor at 159 kHz, so we would expect the response to be down 3dB (.707). Figure 2 is a plot of the source (node 1) and the voltage across R1 (node 2). The delay caused by induction in L1 is seen. As the input voltage increases, the current through L1 increases; the increasing current induces a voltage in L1 that opposes the current increase which causes a lag in the current through R1.

After the input voltage passes its peak, the current wants to decrease but the decreasing current induces a voltage in L1 that opposes the decrease; therefore the output current keeps increasing although at a slower rate. There comes a time when the collapsing magnetic field of L1 cannot sustain the output and the voltage at R1 starts to decrease. The same thing happens on the negative half of the sine wave cycle. Since the current and voltage in a resistor is always in phase, it is not necessary, in this case, to show the current separately.

The inductor reactance increases with frequency until it is much larger than the resistor and practically no signal passes through.



■ FIGURE 1

By Russell Kincaid

ACTIVE AND PASSIVE

Introduction to filters

The impedance looking back into the filter is low (the signal source impedance) at low frequencies and approaches R_{load} at high frequencies.

The reactance of the capacitor decreases with frequency until it is low compared to the resistance and the signal is highly attenuated. The impedance looking back into the filter is $R + X_c$ the source impedance and approaches X_c at high frequencies.

For a high pass filter, swap the location of the resistor and reactive element. The same analysis applies but the output voltage increases with frequency.

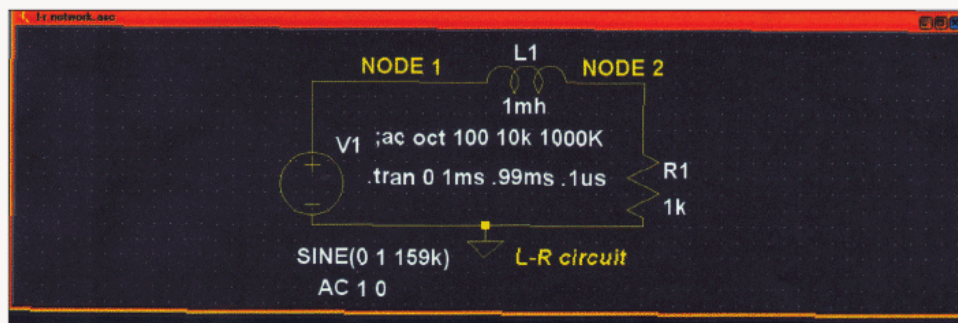
In both cases, when the reactance is equal to the resistance, the output is 0.707 times the input. It is not 1/2 because the reactive element stores energy during part of the cycle and releases it to the resistor during another part of the cycle. This is called the cutoff frequency and the attenuation is -3 dB.

The equation for reactance of the inductor is: $X_L = 2\pi f L$ where $\pi = 3.14159$, f is the frequency in Hz, and L is the inductance in Henries. The reactance of a capacitor is: $X_C = 1/(2\pi f C)$ where C is the capacitance in Farads.

If you plot the attenuation in dB of the simple low pass filter versus frequency using semi-log graph paper, the curve approaches a straight line above the cutoff frequency. The slope of the line is -6 dB per octave of frequency. Cascading another stage of filtering will make the slope -12 dB per octave, and so on. The attenuation at the cutoff frequency also increases, being $N \times -3$ dB where N is the number of stages.

The problem in cascading these simple filters is that, in the case of the inductor input filter, the filter impedance at low frequencies is low and difficult to drive. The R-C filter does not have that problem, but the output impedance is high, requiring a very high load impedance so as not to further attenuate the signal.

One way to overcome these problems is to make a filter with only L and C, no



■ FIGURE 3

resistors except at the source and load. The inductors and capacitors have internal losses that can be represented by resistors, but those losses can be neglected in many cases. We will look at passive L-C filters in the next section.

Another type of filter is the active R-C filter, where feedback is used to overcome the resistive losses. That will be the subject of another article.

The filter introduces a delay in the signal. This can be most easily analyzed using SPICE transient analysis:

Figure 3 is an L-R circuit to be analyzed, first is a SPICE transient analysis using a sine wave source of 159 kHz. The reactance of the 1 mH inductor is equal to the 1K ohm resistor at 159 kHz, so we would expect the response to be down 3 dB (.707). Figure 4 is a plot of the source (node 1) and the voltage across R1 (node 2).

The delay caused by induction in L1 is seen. As the input voltage increases, the current (blue trace) through L1 increases; the increasing current induces a voltage in L1 that opposes the current increase, which causes a lag in the current through R1. After the input voltage passes its peak, the current wants to

decrease but the decreasing current induces a voltage in L1 that opposes the decrease; therefore the output current keeps increasing, although at a slower rate.

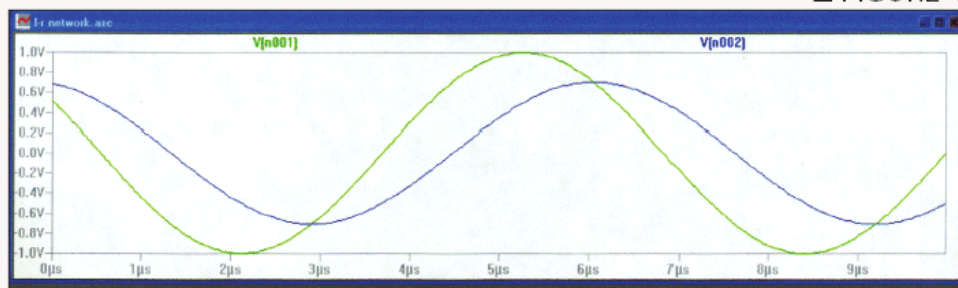
There comes a time when the collapsing magnetic field of L1 cannot sustain the output and the voltage at R1 starts to decrease. The same thing happens on the negative half of the sine wave cycle. Since the current and voltage in a resistor is always in phase, it is not necessary in this case to show the current separately.

Each cycle contains 360 degrees. Measuring the delay of the voltage across R1 as a fraction of the cycle, I get $1.45/11.6 = .125$

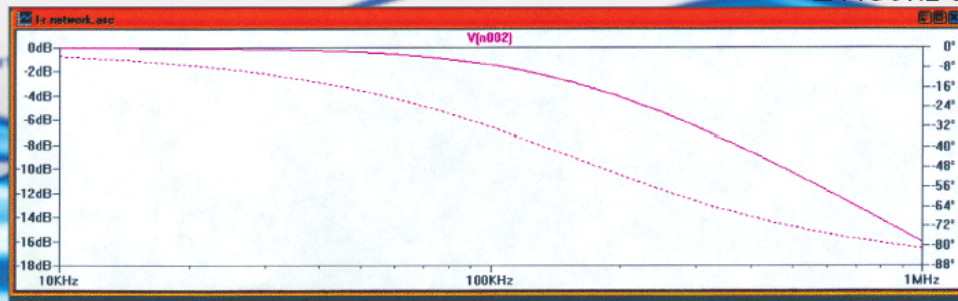
$$.125 \times 360 = 45 \text{ degrees}$$

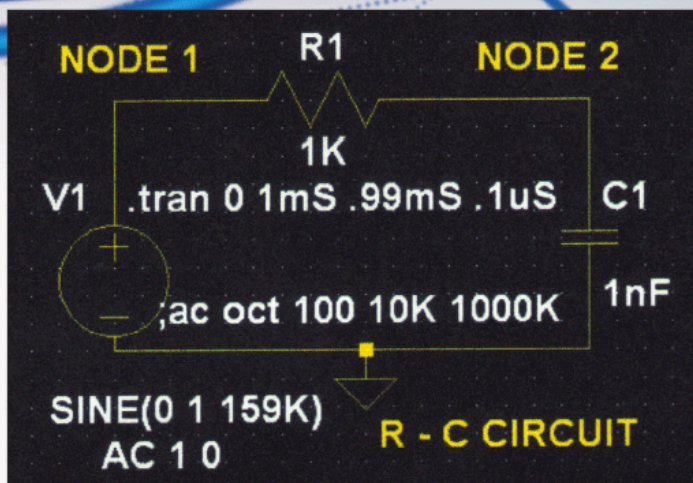
Second, a SPICE frequency sweep (AC) analysis is run from 10 kHz to 1 MHz. The result is in Figure 3. Note that the output at node 1 is nearly equal to the input at 10 kHz because the reactance of L1 is low. At 159 kHz, the output is down 3 dB and

■ FIGURE 4



■ FIGURE 5





■ FIGURE 6

the phase angle is 45 degrees.

As the frequency increases, the reactance of L1 increases causing the output to decrease. The phase angle continues to increase, reaching a limit of 90 degrees at infinite frequency.

Figure 4 is the R-C low pass circuit. The AC analysis in SPICE will be identical to the L-R circuit (Figure 3), because the resistance of R1 is small compared to the reactance of C1 at 10 kHz. As the frequency

increases, the reactance of C1 decreases, causing the output (node 2) to decrease. The transient analysis at 159 kHz will be similar but the current waveform, being compared to the voltage across the capacitor, will not be in phase. The inductor and capacitor are duals in that the voltage across the capacitor is mathematically the same as the current in the inductor, and

vice versa.

Figure 5 is a plot from the transient analysis of the circuit in Figure 4. The voltage on the capacitor lags the input voltage because it takes time for the current to charge the capacitor. The current responds to the voltage difference between the capacitor charge and the input voltage. The maximum voltage difference is at 45 degrees of the input voltage. Thereafter, the current starts to decrease but since it is still flow-

ing in the same direction, the charge on the capacitor keeps increasing. At 45 degrees past the peak of the input voltage, the input voltage and capacitor voltage will be equal and the current will be zero.

As the current increases in the negative direction, it discharges the capacitor. The analysis of an R-L (high pass) circuit will be the same except current in the capacitor becomes voltage in the inductor and vice versa.

Note that the output at node 1 is nearly equal to the input at 10 kHz because the reactance of L1 is low. At 159 kHz, the output is down 3 dB and the phase angle is 45 degrees. As the frequency increases, the reactance of L1 increases, causing the output to decrease. The phase angle continues to increase, reaching a limit of 90 degrees at infinite frequency.

Figure 6 is the R-C low pass circuit. The AC analysis in SPICE will be identical to the L-R circuit (Figure 3) because the resistance of R1 is small compared to the reactance of C1 at 10 kHz. As the frequency increases, the reactance of C1 decreases, causing the output (node 2) to decrease.

The transient analysis at 159 kHz will be similar, but the current waveform, being

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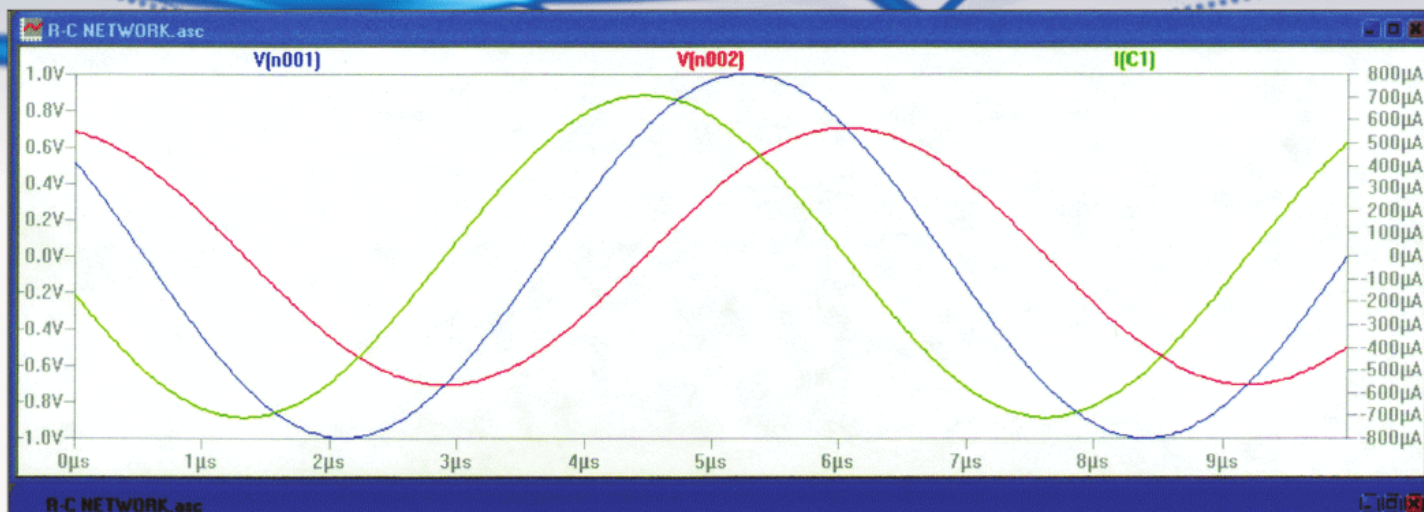


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■ FIGURE 7

compared to the voltage across the capacitor, will not be in phase. The inductor and capacitor are duals, in that the voltage across the capacitor is mathematically the same as the current in the inductor, and vice versa.

Figure 7 is a plot from the transient analysis of the circuit in Figure 6. The voltage on the capacitor (red trace) lags the input voltage (blue trace) because it takes

time for the current to charge the capacitor. The current (green trace) responds to the voltage difference between the capacitor charge and the input voltage. Note that it leads the voltage on the capacitor by 90 degrees. The maximum voltage difference is at 45 degrees of the input voltage. Thereafter, the current starts to decrease, but since it is still flowing in the same direction, the charge on the capacitor keeps increas-

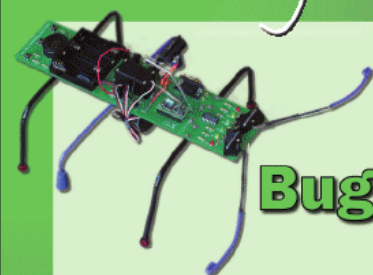
ing. At 45 degrees past the peak of the input voltage, the input voltage and capacitor voltage will be equal and the current will be zero.

As the current increases in the negative direction, it discharges the capacitor. The analysis of an R-L (high pass) circuit will be the same, except current in the capacitor becomes voltage in the inductor and vice versa. ■

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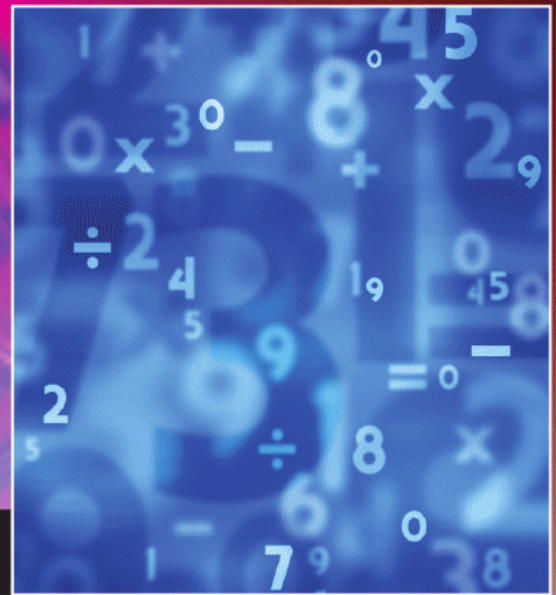
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DATA Processing Using SCAM⁽²⁾ QUERY MANIPULATION

In this article, I describe in detail how the SCAM (Super Content-Addressable Memory) manipulates queries against simple and complex data types. The data is assumed to be stored in a database.



This should demonstrate to application programmers and database administrators how the SCAM enhances data manipulation performance compared to traditional computer configurations.

SIMPLE-DATA MANIPULATION

Here, we deal with data stored in an Employee table within the Company database. Assuming I have no indices built for that table, all records in the table will be cached in the SCAM memory blocks¹ for processing user queries. Each record will reside in a simple structure similar to that depicted in Table 1. I assume that the Employee records are identified with the number 125 loaded in the Structure-ID word which I called the Start-Of-Structure (SOS) word in Part 1.

■ Example 1: Consider this sample query involving forward navigation operation of the SCAM:

```
Select * From Employee Where Name LIKE 'John%' AND Rank='A'
```

■ Example 2: Now, let's consider this sample query that involves the backward navigation operation of the SCAM:

```
Select * From Employee Where Name LIKE '%Don'
```

Below are two examples of SQL² queries to demonstrate how a search operation based on predicate matching is performed using forward/backward navigation capabilities of the SCAM. The examples involve LIKE predicates (i.e., partial pattern matching) using the "symbol%" and "%symbol"³ format, and illustrate how the Tag bits are affected during query processing. It should be noted that loading either the Mask or the Comparand register (or both) using a Write operation is omitted in the illustration for brevity but is implied for each Compare command.

The steps of processing the query (see

Table 1) start by issuing a Set command to set all Tag bits to "1" and thus selecting all words in the SCAM. Then, a Compare command is performed to

select structure delimiter words SOS and to check the Class-ID value. Next, an LNW is issued to select the next word followed by an LNE command to pass the search result to the Name element. Four Compare commands interleaved by an LNW are performed to search for the pattern "John." Then, an LNE command is issued to pass the search result to the Rank element delimiter word and ignore the trailing data of structure-elementName. Another Compare command is issued to check a match for Rank "A." Passing the final query result to the end-of-structure (EOS) delimiter word is possible with an LNW command which will then transfer the Rank search result to the EOS word. A Compare for the (EOS) pattern can then be executed to reset the Tag bits elsewhere in the structure to "0." Only qualifying structures will have their Control Cells of that word set to "1." If an exact match for Name (i.e., Name = "John") is required, then, after checking the pattern matching for "John," an LNW command should be issued instead of

B y G a m a l A l i L a b i b

■ **TABLE 1. QUERY PROCESSING FOR EXAMPLE 1**

LNE, and this should link to the element delimiter of Rank. Otherwise, the exact match fails.

In Example 2, it is possible to match the trailing data of the predicate only with backward linking of structure words. Table 2 illustrates the sequence of commands issued to resolve this query. Note that checking the element delimiter bit of the start-of-element word (SOE) is required to reset the Tag bits elsewhere in the structure to "0." In Example 1, the latter procedure was included in the Compare operation for the first word in the elements Name and Rank.

In the case of resolving nested queries and/or having multiple OR'ed predicates in the same query, it would be necessary to allocate flag words either in structure-element headers/trailers or in the structure header to store intermediate results. Evaluating the final result of the query can then be achieved by processing those flag bits and selecting only qualifying structures. Considering the case of selection conditions being correlated using solely AND operators, the navigation capability of the SCAM would suffice to move the compare activity to the predicate's structure-elements in sequence. The qualifying structures would then be selected automatically, in a way similar to that of Example 1. So, in the latter case, using flag bits will not be required. It should be noted that the methods of querying simple-structures

described in this section can be successfully applied directly to composite-structures only if they are clustered with their constituent-structures.

COMPOSITE-OBJECT MANIPULATION

Here, we consider unclustered objects

	WORD CONTENT	STRUCTURE CELL	ELEMENT CELL	ASCII DATA	TAG BIT CONTENTS													
					Set	Compare	LNW	LNE	Compare	LNW	Compare	LNW	Compare	LNW	Compare	LNE	Compare	LNW
					SOS				J		O		h		n		A	EOS
first structure occurrence	SID	1	0	7D	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	VID	0	1	01	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		0	0	FE	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'J'	0	1	4A	1	0	0	1	1	0	0	0	0	0	0	0	0	0
	'o'	0	0	6F	1	0	0	0	0	1	1	0	0	0	0	0	0	0
	'h'	0	0	68	1	0	0	0	0	0	0	1	1	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	1	1	0	0	0
	' '	0	0	40	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'D'	0	0	44	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'o'	0	0	6F	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'A'	0	1	41	1	0	0	0	0	0	0	0	0	0	1	1	0	0
second structure occurrence	EOS	1	0	10	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	SID	1	0	7D	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	VID	0	0	01	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		0	0	FE	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'J'	0	1	4A	1	0	0	1	1	0	0	0	0	0	0	0	0	0
	'o'	0	0	6F	1	0	0	0	0	1	1	0	0	0	0	0	0	0
	'h'	0	0	68	1	0	0	0	0	0	0	1	1	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	1	1	0	0	0
	' '	0	0	40	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'B'	0	0	42	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'e'	0	0	6C	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	'A'	0	1	41	1	0	0	0	0	0	0	0	0	0	1	1	0	0
	EOS	1	0	10	1	0	0	0	0	0	0	0	0	0	0	0	1	1

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where a join operation is required to merge composite-objects with their constituent objects. In doing so, we find different situations that would require different handling algorithms in the SCAM. That is, we may be dealing with composite-objects having single or multiple instances of their constituent structure-elements. In the first case (e.g., Employee-Spouse), composite-objects are excluded from further checks once they are joined with the first encounter of eligible constituent objects. In the second case (e.g., Employee-Children), composite-structures require repeated checks until all (or some of) the constituent structures of each composite-structure are located⁴.

In this section, I consider the first case and develop the suitable algorithm for assembling the composite-objects in the SCAM. The algorithm covering the second case can be devised based on the discussion that follows.

Now I will demonstrate an algorithm for joining one page of unrestricted composite-objects, loaded in SCAM Block #1, with pages of unrestricted constituent-objects, loaded in sequence into SCAM Block #2 (see algorithm flowchart in Figure 1). I start with simultaneous selection of structures resembling all objects in both blocks according to the predicates of the query. Qualifying objects are marked (by setting a bit in the corresponding structure header). Marked structures in Block#1 (the outer join relation) are served one at a time by retrieving them in sequence into an external buffer memory. The SCAM extracts the constituent Object-ID (similar to the Variable-ID in the relevant structure) from the composite-object and loads it into the Comparator of Block #2. Objects in Block #2 are then searched for that Object-ID, and if the required structure is located, its marking is checked. If the object is marked, it is retrieved and joined with its composite-object

	WORD CONTENT	STRUCTURE CELL	ELEMENT CELL	ASCII DATA	TAG BIT CONTENTS											
					Set	Compare	LNW	LNE	LNW	LNE	Compare	LPW	Compare	LPW	Compare	LPW
					SOS						A	n		o		D
first structure occurrence	SID	1	0	7D	1	1	0	0	0	0	0	0	0	0	0	0
	VID	0	0	01	1	0	1	0	0	0	0	0	0	0	0	0
		0	0	FE	1	0	0	0	0	0	0	0	0	0	0	0
	'J'	0	1	4A	1	0	0	1	0	0	0	0	0	0	0	0
	'o'	0	0	6F	1	0	0	0	1	0	0	0	0	0	0	0
	'h'	0	0	68	1	0	0	0	0	0	0	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	0	0	0
	'..'	0	0	40	1	0	0	0	0	0	0	0	0	0	0	0
	'D'	0	0	44	1	0	0	0	0	0	0	0	0	0	1	1
	'o'	0	0	6F	1	0	0	0	0	0	0	0	1	1	0	0
second structure occurrence	'n'	0	0	6E	1	0	0	0	0	0	0	1	1	0	0	0
	'A'	0	1	41	1	0	0	0	0	1	1	0	0	0	0	0
	EOS	1	0	10	1	0	0	0	0	0	0	0	0	0	0	0
	SID	1	0	7D	1	1	0	0	0	0	0	0	0	0	0	0
	VID	0	0	01	1	0	1	0	0	0	0	0	0	0	0	0
		0	0	FE	1	0	0	0	0	0	0	0	0	0	0	0
	'J'	0	1	4A	1	0	0	1	0	0	0	0	0	0	0	0
	'o'	0	0	6F	1	0	0	0	1	0	0	0	0	0	0	0
	'h'	0	0	68	1	0	0	0	0	0	0	0	0	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	0	0	0	0	0
	'..'	0	0	40	1	0	0	0	0	0	0	0	0	0	0	0
	'B'	0	0	42	1	0	0	0	0	0	0	0	0	0	0	0
	'e'	0	0	6C	1	0	0	0	0	0	0	0	1	0	0	0
	'n'	0	0	6E	1	0	0	0	0	0	0	1	1	0	0	0
	'A'	0	1	41	1	0	0	0	0	1	1	0	0	0	0	0
	EOS	1	0	10	1	0	0	0	0	0	0	0	0	0	0	0

TABLE 2. QUERY PROCESSING FOR EXAMPLE 2

MADELL TECHNOLOGY



AT850B Hot Air Rework Station
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AS-5001 Mini Automatic Reflow Oven
\$798.00



1 GHz Spectrum Analyzer / Function Generator
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AT5010 \$1025.00
AT5010B \$875.00

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STP-350 High Precision Manual Stencil Printer
\$1195.00



SZM7045TR Trinocular Microscope
with Double Bar Boom Stand \$590.00
with Single Bar Boom Stand \$515.00



AE-R330 Tabletop Convection Reflow Oven
\$3950.00



QK5020 20 MHz 2-Channel Analog Oscilloscope
\$250.00

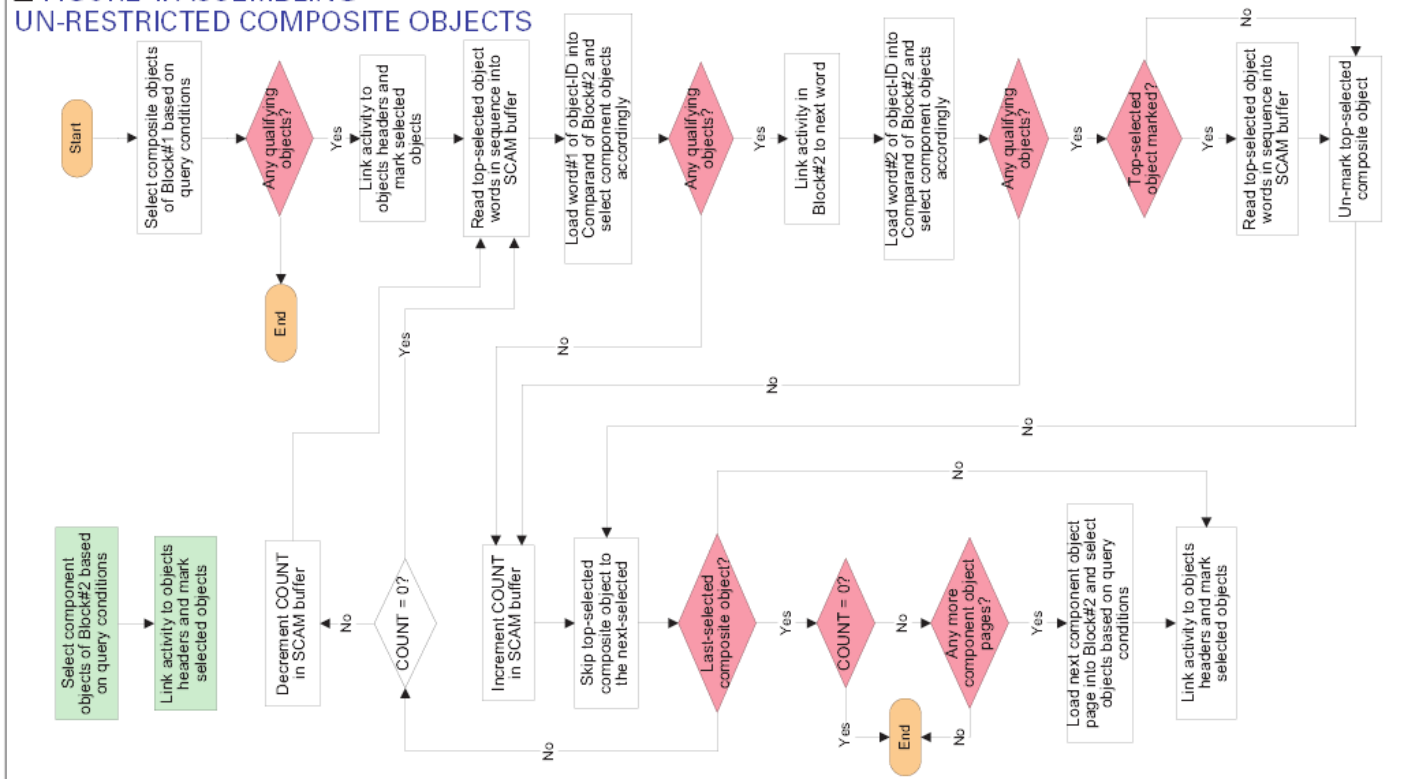


QK702ESD 3-in-1 Rework Station
\$449.00



ZD-9556 Orbital Shaker \$265.00

■ FIGURE 1. ASSEMBLING UN-RESTRICTED COMPOSITE OBJECTS



in the buffer memory; otherwise the composite-object mark is cleared and thus excluded from further checks. If the constituent-object is not located, a counter in the buffer memory is incremented to account for the composite-object in further check passes. Composite-objects are served one at a time. The next qualifying composite-object is made the top-selected one.

Following that service pass, the counter is checked. If it is zero, then the join is concluded. Otherwise, another page of constituent structures (if any) is loaded into Block #2, checked against query predicates, and marked. The join operation then resumes for the remaining marked composite-structures. Each successful join for a composite-object following the first pass results in decrementing the counter in the buffer memory. When the counter is back to zero, the join ends and another page of composite-object (if any) may be loaded into Block #1 and served.

The cost of executing this algorithm is calculated using a deduced formula that shows a tenfold speed-up of the SCAM compared to RAM-based systems. Executing queries using the SCAM require translation into sequences of SCAM operations. The translation process can be carried out by a preprocessor dedicated for that purpose.

In the next article, I will describe how to

1 — The SCAM chips/devices may be cascaded to accommodate large sets of data.

2 — Reference to SQL can be found in: Vossen, G., "Data Models, Database Languages and Database Management Systems," Addison-Wesley, 1990, chapter 16, pp. 307-363.]

3—The % symbol is a placeholder for a sequence of zero or more arbitrary symbols.

4 — Depending on the query.

measure the performance of the SCAM in executing each operation and query, and pres-

ent adapted logic and mathematical algorithms that can be manipulated using the SCAM. ■

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REVIEW

By James L. Antonakos

Performance Electronics for Cars

from the publishers of
SiliconChip

This book has 160 pages dedicated to constructing electronic kits for controlling, monitoring, and tuning automotive systems. The book contains 23 chapters and is divided into four sections.

The first section provides coverage of the technical essentials required to work with automotive electronics.

This includes engine management methods (electronic fuel injection, valve timing, automatic transmissions, turbo boost control, and so forth), instructions on how to modify your car's electrical and electronic systems, construction tips for building electronic kits, and the purpose and use of a digital multimeter.

The remaining three sections contain 16 projects organized into the following categories:

- Instruments (three chapters)
- Switches and Timers (five chapters)
- Modifiers and Controllers (eight chapters)

Each chapter has an explanation of the circuit and what it is used for, a schematic of the circuit and an explanation of how it works, construction tips, parts list, cabling

■ TABLE 1. WORLDWIDE LOCATIONS FOR JAYCAR ELECTRONICS.

LOCATION	ADDRESS
US and Canada	www.jaycarelectronics.com
Australia	www.jaycar.com.au
New Zealand	www.jaycar.co.nz
United Kingdom	www.jaycarelectronics.co.uk

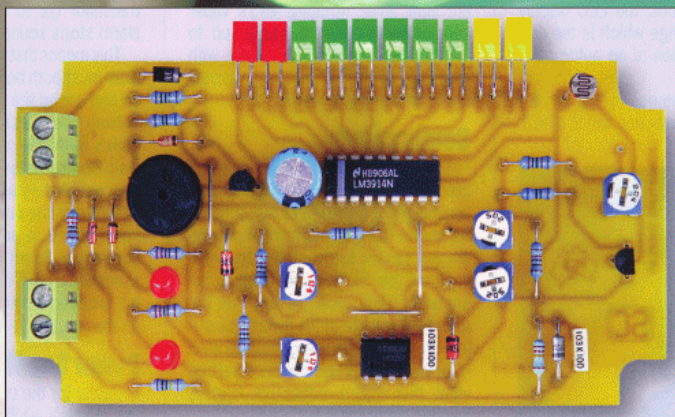
diagrams, and typically one or more photographs of the completed kits and the modifications necessary to the cars during installation. Many chapters have graphs or charts illustrating various performance characteristics and the effect of the electronic kit on the engine. All of the electronic kits highlighted in the book are available from Jaycar Electronics stores and dealers in several major locations, as indicated in Table 1.

The kits range in price from a few dollars to a few hundred, with many kits priced less than \$30. Each kit contains an etched and drilled printed circuit board, one percent metal film resistors, MTK-style plastic capac-

Performance Electronics For Cars

A BOOK REVIEW

Many chapters have graphs or charts illustrating various performance characteristics and the effect of the electronic kit on the engine.



■ FIGURE 1. FULLY ASSEMBLED CIRCUIT BOARD FOR THE SMART MIXTURE METER.

itors and IC sockets (as required), and other high-quality components. Even individuals who have never soldered before are shown the steps required to make a good connection, the tools required, and simple steps for constructing a working circuit.

Let's take a look at three of the automotive kits available from Jaycar. Each kit comes from one of the three project sections in the book.

From the "Instruments" section, we will examine the first project, the Smart Mixture Meter. This circuit monitors your car's oxygen and airflow sensors and provides a real-time visual indication of the air-fuel ratio (Red for lean, Yellow for rich, and Green

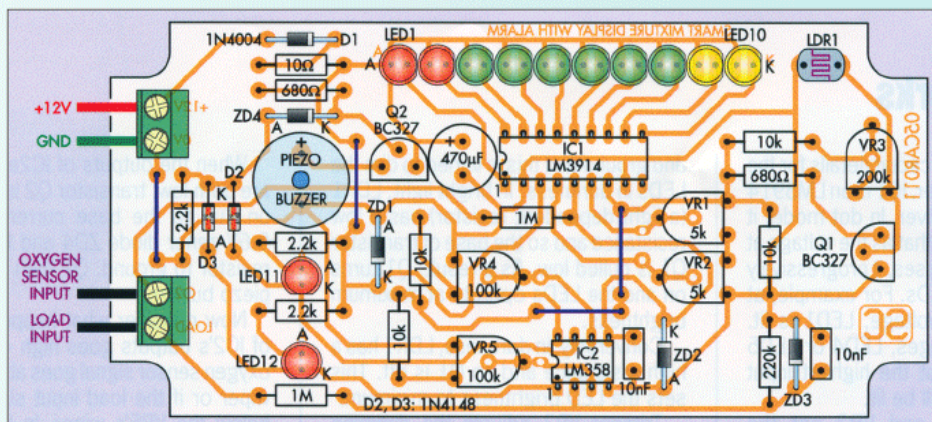
for the mid-range). Figure 1 shows the completed circuit board. Trimmer potentiometers are used to calibrate the circuit and adjust its operating characteristics. Connectors for off-board wiring make it easy to connect the Smart Mixture Meter to your car's electrical system. Figure 2 shows the component placement diagram and off-board cabling signals. The layout of the components is neat and well organized, with no components crowded together. Figure 3 shows the schematic of the Smart Mixture Meter. Almost every type of electronic component is present. While this project may be challenging enough for a beginner, there are other, more complex projects in the book to satisfy those

looking for more.

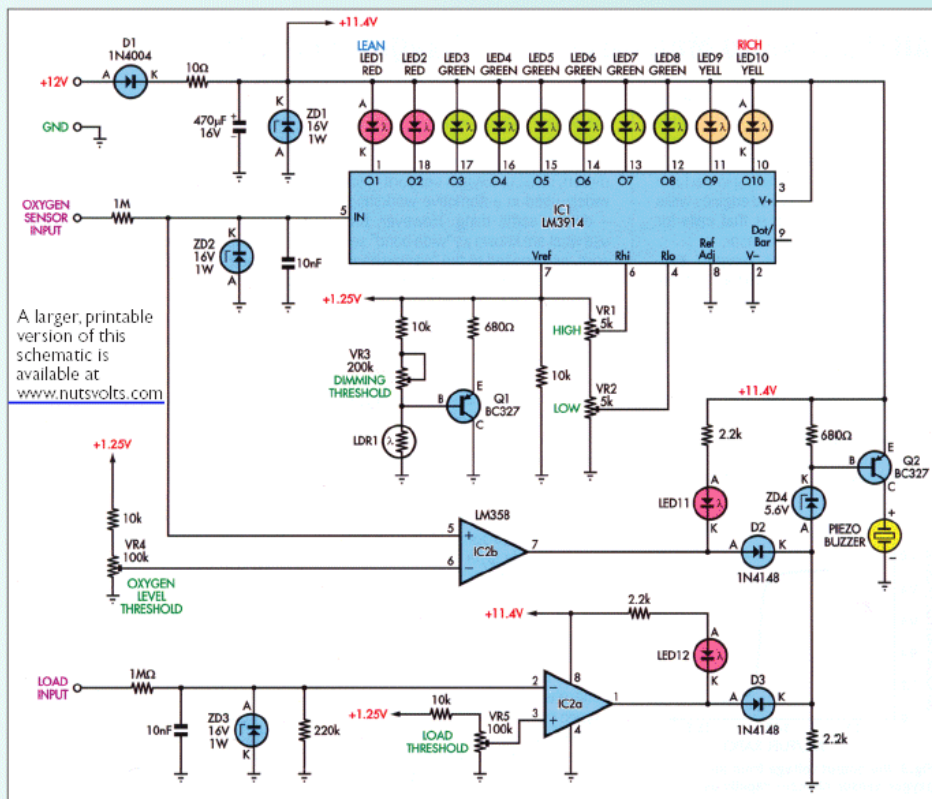
For example, from the "Switches and Timers" section, let us look over the High Temperature Digital Thermometer, whose circuit board is shown in Figure 4. This circuit is a little more complicated than the Smart Mixture Meter, and can be used to measure temperatures up to 1,200 deg C. The High Temperature Digital Thermometer can also switch a load on or off at a preset temperature via an on-board DPDT relay.

From the "Modifiers and Controllers" section, consider the Digital Fuel Adjuster, the main electronics of which are shown in Figure 5. This is one of the most complex projects in the book. The Digital Fuel Adjuster can be used

■ FIGURE 2. COMPONENT AND CABLING DIAGRAM FOR THE SMART MIXTURE METER.



■ FIGURE 3. SCHEMATIC OF THE SMART MIXTURE METER.



A larger, printable version of this schematic is available at www.nutsvolts.com

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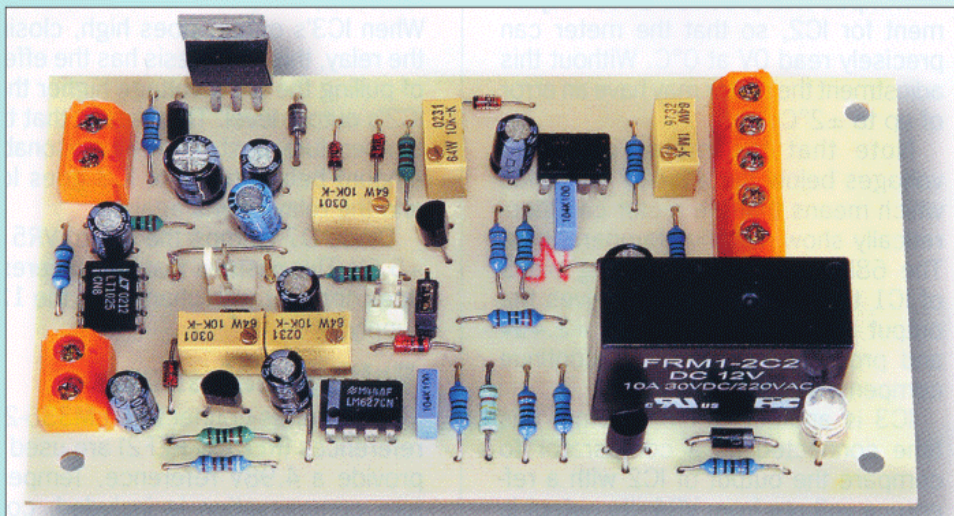
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AX2550	2x120A	A	\$495
AX2550HE	2x140A	A	\$645
AX2850	2x120A	O-A	\$620
AX2850HE	2x140A	O-A	\$770

A=Aluminum Extrusion, B=Board-Level, O=Optical Encoder In, R= RC outputs. Qty1 price. Contact us for OEM Qty prices

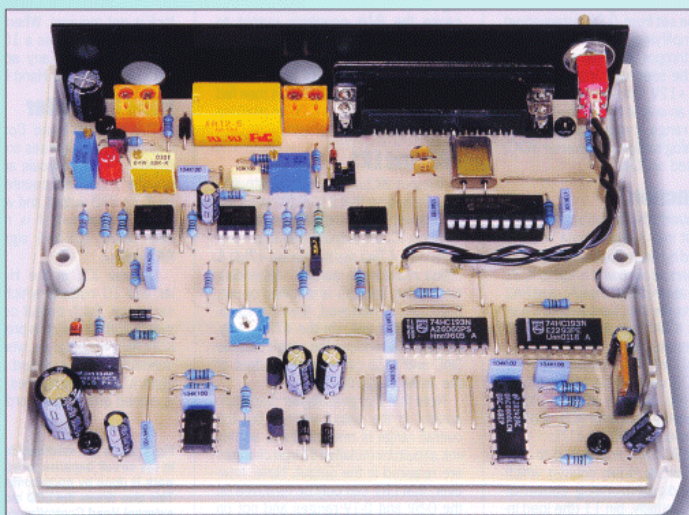
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■ FIGURE 4. THE HIGHTEMPERATURE DIGITAL THERMOMETER CIRCUIT BOARD CONNECTS TO ANY K-TYPE THERMOCOUPLE AND LCD OR LED DISPLAY MODULE.



■ FIGURE 5. ASSEMBLED DIGITAL FUEL ADJUSTER CIRCUIT BOARD MOUNTED IN A STANDARD PLASTIC INSTRUMENT CASE.

TABLE OF CONTENTS

Here are the chapter topics presented in *Performance Electronics for Cars*:

TECH BACKGROUND

- 1: Understanding Engine Management
- 2: Advanced Engine Management
- 3: Other Electronic Systems
- 4: Modifying Car Electronic Systems
- 5: DIY Electronic Modification
- 6: Building Electronic Project Kits
- 7: Using a Multimeter

INSTRUMENTS

- 8: Smart Mixture Meter
- 9: Injector Duty Cycle Meter
- 10: High Temperature Digital Thermometer

SWITCHES AND TIMERS

- 11: Versatile Auto Timer
- 12: Simple Voltage Switch
- 13: Temperature Switch
- 14: Frequency Switch
- 15: Delta Throttle Timer

MODIFIERS AND CONTROLLERS

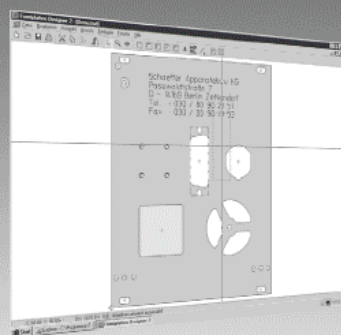
- 16: Digital Pulse Adjuster
- 17: LCD Hand Controller
- 18: Peak-Hold Injection Adaptor
- 19: Digital Fuel Adjuster
- 20: Speedo Corrector
- 21: Independent Electronic Boost Controller
- 22: Nitrous Fuel Controller
- 23: Intelligent Turbo Timer

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to adjust air-fuel ratios and change closed-loop running characteristics, among other things. The main electronics connect to a hand-held programming and display module that contains a two-line LCD alphanumeric display for indicating settings and the system's mode of operation.

Whether you are just a beginner or a seasoned expert, there is a project waiting for you inside Silicon Chip's *Performance Electronics for Cars*. So, visit one of the Jaycar websites listed in Table 1 and get started on the road to improving your car's performance, electronically. ■

James Antonakos is a Professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College. With over 29 years of experience designing digital and analog circuitry and developing software, he is also the author of numerous textbooks on microprocessors, programming, and microcomputer systems. You may reach him at antonakos_j@sunybroome.edu or visit his website at www.sunybroome.edu/~antonakos_j.

HOP TO IT



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Theremin Synthesiser Kit

KC-5295 \$35.00 + post & packing

The Theremin is a weird musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. By moving your hand between the antenna and the metal plate, you create strange sound effects like in those scary movies! Kit includes a machined, silk screened, and pre drilled case, circuit board, all electronic components, and clear English instructions.



9VDC wall adaptor required (Jameco #252751 \$10.95).



'Clock Watchers' Clock Kit Now with Blue LEDs

KC-5416 \$110.25 + post & packing

It consists of an AVR driven clock circuit, and produces a dazzling display with the 60 blue LEDs around the perimeter. It looks amazing, but can't be properly explained here. We have filmed it in action so you can see for yourself on our website, so check it out! Kit supplied with double sided silkscreened plated through hole PCB and all board components as well as the special clock housing and clear English instructions.

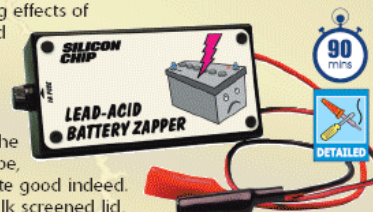


Lead-Acid Battery Zapper Kit

KC-5414 \$23.25 + post & packing

Lead acid batteries are very common in modern life, and are a very versatile power source. Unfortunately, the chemical reaction inside the cells can be the very thing leading it to a premature death. This simple circuit is designed to produce bursts of high-energy pulses to help reverse the damaging effects of sulphation in wet lead acid cells. This is particularly useful when a battery has been sitting for a period of time without use. The effects are dependant of the battery's condition and type, but the results can be quite good indeed.

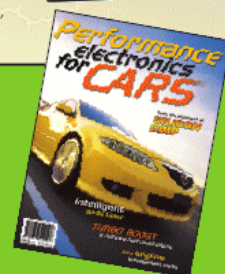
* Kit supplied with case, silk screened lid, leads, inductors, all electronic components, and clear English instructions



High Performance Electronic Projects for Cars

BS-5080 \$13.60 + post & packing

Australia's leading electronics magazine Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers, and more! The book includes all instructions, components lists, color pictures, and circuit layouts. There are also chapters on engine management, advanced systems and DIY modifications. Over 150 pages! All the projects are available in kit form.

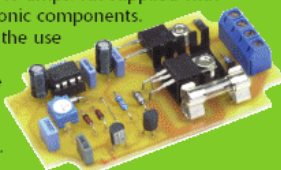


Nitrous Fuel Mixture / Motor Speed Controller

KC-5382 \$14.40 + post & packing

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NEAR SPACE

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THE WELL-DRESSED ASTRONAUT

TODAY'S SPACE SHUTTLE SPACESUIT doesn't make a good spacesuit for planetary exploration because of the differences between working in weightlessness for a single mission and working on a dusty, gritty planet with gravity for months on end.

To make a good planetary suit, the Space Shuttle spacesuit would need to be easier to wear, clean, maintain, and personalize. So with plans to go back to the Moon and then eventually to Mars, astronauts need a new generation of spacesuit, the planetary suit. The International Latex Corporation and the David Clark Company are working with NASA to develop and test the technologies that will go into tomorrow's planetary suit. Before discussing some of these technologies, let's briefly look at the dangers of high altitude flight.

SOME EARLY (AND BAD) EXPERIENCES AT HIGH ALTITUDE

In 1862, aeronauts James Glaisher and Henry Coxwell made their first scientific balloon flight to explore the high troposphere. By the time they reached 30,000 feet, Glaisher had passed out due to the lack of air. Both aeronauts would have died had Coxwell not opened the balloon's vent. The chilling cold made it impossible to use his hands, so Coxwell used his teeth to pull the balloon vent open.

In 1927, Army Air Service Captain Hawthorne Gray made several flights into the high troposphere. He did not wear a pressure suit but did take an oxygen mask on his later flights. Gray made his last flight in November of that year. His final log entry mentions how the cold air was interfering with his ability to function. Gray was found at the end of his flight, in a tree and slumped over in his opened gondola. The cause of death is not certain, although it's believed the lack of oxygen was the primary factor.



■ A1C SUITS

PROTECTING HUMAN LIFE AT HIGH ALTITUDE

At first glance, you'd think that providing oxygen and warm clothing would be enough to keep humans alive at high altitude. Unfortunately, breathing at a lower pressure also means getting less oxygen. Not even 100% oxygen is enough to keep a person alive once the air pressure drops below about 0.7 pounds per square inch (PSI).

Forcing more oxygen into the lungs is not the solution. As little as one PSI over pressure is enough to rupture the lungs. Needless to say, with a pair of ruptured lungs it doesn't matter how much oxygen a person receives. So, along with getting enough oxygen in each breath of air, pressure must be exerted against the torso to make breathing safe.

A spacesuit must also protect the body from the other harmful effects of low pressure. One effect is the release of nitrogen bubbles from body fluids. This effect, called the bends, results in severe pain and even death. Even if the bends are prevented, low air pressure can create severe pain as the internal pressure of the body presses outward on the skin. A second effect of low air pressure is the lowering of the boiling point of liquids. Above an altitude of 63,000 feet, the air pressure is so low that body fluids like blood and saliva boil. If the bends don't kill you, boiling blood will.

Normally, when we exhale, the air dilutes the carbon dioxide in our breath to safe levels. Breathing oxygen through a mask can prevent this dilution. When carbon dioxide is not scrubbed from our breath, its concentration in our blood builds up and, as a result, the cells in our

body are poisoned. The effects of carbon dioxide poisoning begin with the brain and result in poor decision making. Eventually, unconsciousness and death are reached. (Note that this is a separate issue from carbon monoxide poisoning.)

The Earth's atmosphere is very cold at high altitude. The cold temperature can be a minor nuisance or can result in frostbite and death. In outer space, it tends to be cold when an astronaut is shaded from the Sun, but direct exposure to sunlight can still result in burns.

When looking at the dangers of high altitude, we can see that a spacesuit must meet the following requirements if the wearer is to stay alive and functional.

- ▶ *Provide oxygen to keep the body alive and the brain mentally sharp*
- ▶ *Protect the body from the effects of low pressure*
- ▶ *Remove (or scrub) carbon dioxide from exhaled air*
- ▶ *Maintain a safe and comfortable temperature*

While protecting life, a space suit cannot excessively inhibit the mobility of its wearer. Doing so makes movements fatiguing or impossible. Since there's no protection from micrometeoroids in space, the space suit must also protect its integrity from damage by micrometeoroid impacts. Not only can these impacts compromise the functioning of the spacesuit, they can also injure the wearer.

THE FIRST PRESSURE SUIT

For well over 100 years, knowledgeable people have known that you can't survive at extremely high altitudes, or in outer space, without protection from the cold and vacuum. By the early 20th century, pilots like Willey Post had discovered that aircraft flew faster when they flew higher (they had discovered the jet stream). But without some form of protection from the elements, the pilots and their passengers would suffer from the effects of cold and low air pressure.

One solution was to make the cabin of the aircraft airtight. This way enough heat and air could be maintained for the crew. However, this required air seals and airtight volumes, which would make the aircraft too heavy. Since only the pilot needed protection, it was decided to build a pressure suit for the pilot instead.

Willy Post asked the B.F. Goodrich Company for help designing a pressure suit. Their first pressure suit was made from rubberized parachute fabric. The fabric was cut and sewn

so that it wouldn't stretch from the movements of Post. Gloves and socks were molded into the suit to maintain its airtight seal. Regular leather boots were worn over the socks to protect the feet of the suit from abrasion. The suit's helmet was a simple cylinder that bolted to the neck of the pressure suit. Air entered the helmet on the left side of its round portal window. The cost for the suit was \$75 and made Post look a lot like a deep-sea diver.

Before flying with the suit, it was tested on the ground. Entry into the pressure suit was through the neck. After Post donned the suit, its helmet was attached and the suit filled with oxygen. Enough air was added to the suit to simulate the pressure it would experience during flight. The suit design wasn't strong enough to handle the pressure and,

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as a result, the suit ruptured between the torso and legs.

A metal clamp was added between the torso and legs in the redesigned pressure suit. Post again donned the suit for its pressure test. This test took place on a hot day and before long, Post began suffering from the heat. But, the suit was so tight that Post couldn't remove it. To get Post out of the suit, B.F. Goodrich engineers began cutting him out of it. The tightness of the suit made this a long and difficult procedure, so Post was moved to a refrigerated golf ball storage room where he could remain cool while he was carefully cut out of the suit.

Additional modifications were made to the third design. The third suit had a larger neck opening to make it easier to get into and out of the suit. It was assembled in the seated position so Post wouldn't have to exert effort just to remain seated in the aircraft. Metal rings were molded into the suit above and below joints like the knees and the fabric was then bunched up between the rings to make the joints more flexible. The suit's pressure gauge plugged into the knee and a bottle of liquid oxygen was used to pressurize the suit. Testing showed that Post finally had a functional pressure suit.

Post flew to an altitude of 50,000 feet wearing the suit. Unfortunately, one of the official barometers onboard the airplane failed, so the flight didn't qualify for the record. Upon landing at Murdoc dry



■ MERCURY MISSION

lakebed, Post exited his airplane and asked a stranger for help removing the helmet. The wind sail car enthusiast almost passed out from the sight of Post in this pressure suit (think of a similar scene from the movie, *Back To The Future*).

IMPROVING MOBILITY

Wiley Post's pressure suit worked, but it was too uncomfortable to wear for long periods of time. When pressurized, the suit was so stiff that it made operating the airplane difficult. An improved method for increasing the flexibility of the pressure suit was required.

To understand the challenges that pressure suit designers face, get a long and narrow balloon. Try bending the balloon before filling it with air. Now fill the balloon with air and try bending it again. The more you fill the balloon, the more difficult it is to bend. This is

the problem pilots are up against, except every joint of their body is being restrained from bending.

Balloons resist being bent because, as you bend them, you're decreasing their volume and increasing their internal air pressure. When you bend an inflated balloon you're not working against the rubber skin of the balloon, you're working against the balloon's internal pressure. You can vent some of the balloon's air to make it easier to bend. In fact, this is just what cosmonaut Alexei Leonov did to get back into the airlock of the Voskhod 2 space capsule. However, this is a very dangerous way to solve the bending problem of a pressure suit.

Tomato worms are up against the same bending problem. They have long and narrow bodies that are internally pressurized. The way evolution solved this problem was to add accordion-like ridges or pleats to their bodies. The next generation of pressure suits took a clue from the tomato worm and added accordion-like ridges around the areas where the suit needed to bend, like the knees and elbows.

THE MILITARY FULL AND PARTIAL PRESSURE SUIT

With the advent of high-altitude high-speed jet flight, a new requirement emerged. During high G-maneuvers, pilots risked blacking out when blood left their brain and collected in their torso, arms, and legs. So now, pilots needed protection from the accidental depressurization of the cockpit, as well as help flying high G-maneuvers.

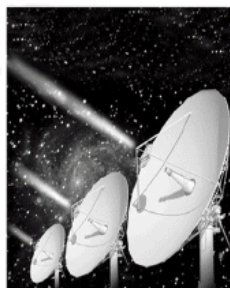
Tight fitting clothing can be used to press against the body and force blood back into the brain during high G-maneuvers. A bladder sewn into the chest and tubes sewn into the outsides of the arms and legs would fill with air and pull the loose suit tightly against the pilot's body, but under normal flying conditions the clothing would be loose and comfortable. These suits are called G-suits. The first example was the S-1, which was developed by the University of Southern California in support of the X-1 program.

The David Clark Company modified the S-1 into the T-1 by combining a G-suit with the partial pressure suit. In the partial pressure suit, air pressure is only maintained around the pilot's face. The rest of the body only experiences pressure through the constriction of the suit. A tight facemask and neck seal kept pressurized oxygen from leaking out of the mask. It was the T-1 that the early test pilots, such as Chuck

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Yeager, wore on flights of the Bell X-1.

The need to fly longer and higher motivated both the Navy and Air Force to develop a full pressure suit. Due to funding constraints, however, development was left to the Navy while the Air Force continued refining the partial pressure suit.

Several full pressure suits were developed in the 1950s. The David Clark Company developed a full pressure suit that eventually became the A/P22S-2, and B.F. Goodrich developed five full pressure suit models (the Mark I to the Mark V).

The A/P22S-2 consisted of a neoprene-coated nylon inner layer to retain air and outer layers of fabric to protect the airtight inner layer from abrasion and sunlight. The oxygen mask of the partial pressure suit was replaced with a helmet. To prevent the suit from ballooning out when filled, the David Clark Company added a layer resembling a nylon fish net over the air bladder layer. The A/P22S-2 full pressure suit was worn by pilots in the X-15 program.



■ MERCURY PROJECT SUIT

There were four layers in the Mercury spacesuit. A rubber-coated, double-walled nylon formed the primary pressure vessel, a neoprene-coated layer formed an extra protection layer, and aluminized nylon formed the outer layer for flame and abrasion protection. The long john underwear worn by the astronaut was the fourth and innermost layer of the suit. Since the astronauts remained inside the capsule for the entire flight, there was no need for thermal protection layers as would be needed in the Gemini, Apollo, and the Space Shuttle.

In case of a capsule decompression, the spacesuit rapidly filled with oxygen supplied by the Mercury capsule. The spacesuit was very stiff when filled, but bending in the suit was made a little easier by break lines sewn into the spacesuit. However, the break lines didn't let the spacesuit maintain a constant pressure during bending, so it still took some effort to bend limbs. The cost for

each Mercury spacesuit was about \$5,000, and half of that was just for the helmet.

Modifications were made to the Mercury spacesuits throughout the program. Alan Shepard's spacesuit was the only one that didn't include a urine collector, as you may recall in the movie, *The Right Stuff*. After Shepard's flight, this vital comfort was added to the suit. Another change was the inclusion of tiny light bulbs sewn into the gloves so astronauts could read the capsule's panels during orbital night.

SPACESUITS OF THE MERCURY PROJECT

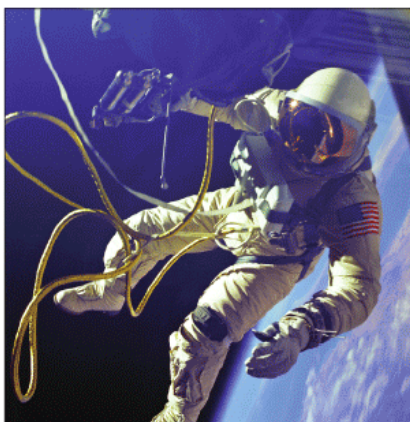
Project Mercury was tasked with getting an American into space and bringing him back safely. There was no plan for the astronauts to leave the Mercury capsule so it remained airtight for the entire flight. However, in the event of a depressurization, the astronauts needed a spacesuit to keep them alive long enough to return to Earth. For the Mercury spacesuit, B.F. Goodrich modified a version of the Navy's full pressure suit, the Mark IV.

To get into and out of the Mercury spacesuit required manipulating 13 zippers. The spacesuit maintained an atmosphere of pure oxygen at 5 PSI of pressure, so in a vacuum, the astronauts breathed more oxygen than we do at sea level (where the partial pressure of oxygen is only about 3 PSI). The temperature was controlled by adjusting the temperature of the oxygen flowing into the suit. Oxygen entered the suit at the waist, flowed around the body, and exited out of the helmet by the right ear. This movement of air kept the astronaut cool and dry. Air exiting the spacesuit was passed through activated charcoal to remove body odors and lithium hydroxide to remove carbon dioxide.

■ MERCURY G5 SUIT



■ GEMINI G4C SUIT



■ GEMINI G3C SUITS



SPACESUITS OF THE GEMINI PROGRAM

The Gemini Program flew 12 flights between Mercury and Apollo and taught NASA how to perform extravehicular activities (EVA), dock spacecraft, and live in space for extended periods of time.

Three types of spacesuits were designed for the Gemini program. The first Gemini spacesuit was the G3C and was worn as an intravehicular suit (for astronauts who weren't leaving the capsule for a space walk). Like the previous Mercury spacesuits, the G3C provided air, temperature, and humidity control through the spacecraft's life support system. This means the spacesuit was left plugged into the spacecraft during the entire mission. Air flowed into the chest, through the helmet to clear the visor, around the body, over extremities, and exited the suit.

The G3C weighed 24 pounds.

The layers of the G3C consisted of a comfort layer (light weight oxford nylon), pressure bladder (neoprene coated nylon), a restraint layer (linknet restraint layer), bumper layers, and an outer covering of Nomex. The astronaut still wore cotton long john underwear. The G3C was designed for a temperature range of -76°F to 327°F. Because the G3C couldn't be used to make an EVA, if a space walking astronaut was unable to get back to the Gemini, the second astronaut (who was wearing a G3C) would be unable to get out and help him.

The second spacesuit was the G4C and was designed for the astronauts who performed an EVA. The G4C was the G3C with added layers of thermal and micrometeoroid protection. The micrometeoroid and thermal protection consisted of several alternating layers of aluminized Mylar and Dacron covered with a felt layer. You can picture the thermal layers as alternating layers of aluminized space blanket and wedding veil material. The additional layers were located between the bumper layer and the outer Nomex layer. These layers made the G4C 10 pounds heavier than the G3C.

The G4C was unable to handle strenuous exertion by the astronauts. A good illustration of this is Gene Cernan's experience. Cernan was to test the Astronaut Maneuvering Unit, or AMU, during *Gemini 9*. The AMU used hydrogen peroxide rocket engines to create thrust and, to protect Cernan's legs from the hot exhaust, he wore a pair of metal chaps over the legs of the suit (made from linked Chromel-R).

As Cernan struggled to walk to the back of *Gemini 9* and attach himself to the AMU, he started overheating and fogged the inside of his visor. Remember, water doesn't drip down in the weightlessness of space. So the fogged visor prevented Cernan from seeing clearly out of his visor. The other Gemini astronauts wiped anti-fog compound on the inside of their visors, but Cernan was not told about this. In his struggle, Cernan ripped the insulation layers in the back of his spacesuit, allowing solar heat to penetrate the suit and add to his discomfort.

Upon getting back into the Gemini, he experienced extreme discomfort trying to bend enough to sit on his couch and shut the hatch of the Gemini. Not until the Gemini was repressurized could Cernan bend enough to get comfortable. Cernan sweated off about 10 pounds,

and that sweat remained inside of his spacesuit until they returned to Earth.

An extended mission to the Moon could be completed within 14 days. But in the mid-1960s, it was not known if humans could handle the effects of weightlessness that long. *Gemini 7* was an endurance test to see if a manned mission to the Moon was possible. Since the standard G3C was too uncomfortable for a 14-day mission, a 16-pound version called the G5C was designed for astronauts Frank Borman and Jim Lovell.

The *Gemini 7* astronauts could don and doff the G5C on their own, unlike the G3C, which required the help of a ground crew. In the cramped Gemini, it still took the astronauts about an hour to don and doff the suits. A soft helmet was sewn into the suit and was opened by a zipper in the neck. The helmet could be rolled up to form a headrest for the astronaut. It should be noted that Mission Control was hesitant about having both astronauts out of their spacesuits at the same time.

SPACESUITS OF THE APOLLO PROGRAM

The Gemini program demonstrated the limitations of the Gemini spacesuit design. If Apollo astronauts were going to work on the Moon, then their spacesuits would need to be more flexible and comfortable.

Two spacesuits were designed for Apollo. The first design, which was worn by the *Apollo 1* and *7* astronauts, closely resembled the Gemini G3C spacesuit. This spacesuit was developed by the David Clark Company and called the A1C. The second spacesuit was developed for the moonwalkers and a variation of it was also worn by the astronaut that remained in lunar orbit.

This spacesuit was called the A7L and was developed by the International Latex Corporation (ILC). Later, the A7L was modified into the A7LB for the extended stays on the Moon by the last three Apollo missions. The moon suits were referred to as an Extravehicular Mobility Unit, or EMU. A total of 60 Apollo EMUs were built at a cost of \$90 million.

Some of the differences between the Gemini and Apollo spacesuits were brought about because of the differences between the Gemini and Apollo missions. For example, the A7L supported an astronaut who was totally free of the spacecraft, or Lunar Module in this case, while the G4C supported an astronaut tethered to the space capsule. The boots of the A7L were designed for walking while the G4C boots only protected the feet of the spacesuit. The gloves of the A7L allowed moonwalkers to use geologic tools on the lunar surface and have an improved sense of feel, while the G4C gloves provided only for flexibility and not tactile sense. Finally, the visor of the A7L helmet increased visibility over the G4C visor.

FREEDOM FROM THE LUNAR MODULE

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oped by Hamilton Standard, the Apollo PLSS carried oxygen, batteries, lithium hydroxide carbon dioxide scrubbers, water cooler, fan, radio, and emergency oxygen. Oxygen was pressurized to 3.7 PSI and fed into the astronaut's helmet and suit. The first Apollo lunar missions had a four-hour supply of oxygen and the PLSS weighed 65 pounds on Earth, or 11 pounds on the Moon. Because of the PLSS, Apollo astronauts kept cool in a way entirely different than the earlier Mercury and Gemini astronauts.

Apollo astronauts wore the liquid cooled garment, or LCG, to keep cool. The LCG was made of thin PVC tubing (Tygon) sewn into a nylon spandex suit and inner layer of nylon tricot for comfort (Klingons probably use a wool comfort layer). The water temperature was set to 70°F and kept the astronaut cool at various levels of exertion. Water flowing through the LCG was chilled through a sublimator in the PLSS.

THESE (MOON) BOOTS ARE MADE FOR WALKING

Like the spacesuit, moon boots were made up of fabric layers for thermal, abrasion, and micrometeorite protection. The boots looked a lot like oversized rain boots. The soles of the boots were made from mold-pressed silicon rubber for insulation, flexibility, and traction.

GLOVES AND HELMET

The gloves of the Apollo EMU were more flexible than those in the Gemini spacesuit. To add a sense of touch to the gloves, silicon rubber pads were sewn into the fingertips. The outer layer of the gloves consisted of a layer of Chromel-R for high temperature resistance. The gloves were not perfect, however. The astronauts had to cut their fingernails short and exercise their hands while training for their mission. Apollo astronauts still experienced painful fingertips after working on the Moon.

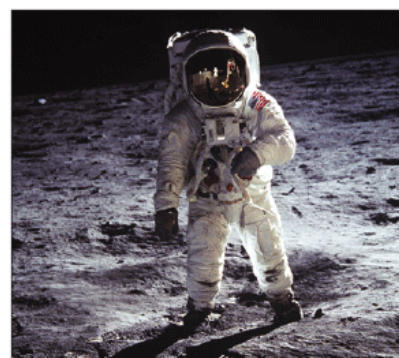
For increased visibility, the Gemini helmet and visor were replaced with a single-piece clear bubble helmet of polycarbonate plastic. A fabric hood went over the early Apollo helmets to block sunlight from shining into the helmet. In addition to increasing visibility, the single piece helmet also increased the A7L's reliability by removing the airtight seal needed in the Gemini helmet visor. The outside of the helmet had two visors that could be lowered, similar to sunglasses.

A7LB MODIFICATIONS

The later, long duration missions used a modified PLSS that held seven hours of oxygen, more cooling water, more lithium

■ APOLLO A7L SUIT

hydroxide, and 75 minutes of emergency oxygen. The weight of this PLSS was 212 pounds on Earth, or 35 pounds on the Moon. Modifications in the PLSS also allowed astronauts to buddy breathe (share oxygen from a single PLSS) should one PLSS fail. The helmet's



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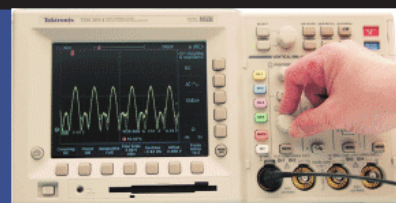
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■ APOLLO A7LB SUIT

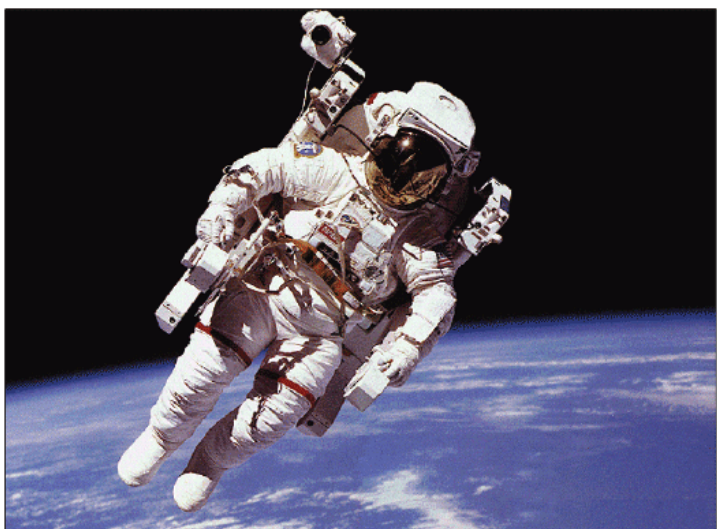
cloth hood was replaced with a set of flaps that the astronaut could position to block sunlight. A minor modification involved identification. Once inside an EMU, it was difficult to tell who was who. By *Apollo 14*, the commander was identified by the red stripes sewn into his EMU.

SPACESUITS OF THE SPACE SHUTTLE

There are a lot more Space Shuttle astronauts than there were Mercury, Gemini, and Apollo astronauts combined. To keep the cost of spacesuits from getting out of hand, the Space Shuttle spacesuits, or EMUs, are designed to fit multiple astronauts. Unlike past spacesuits, the EMU only serves one function, and that's for making space walks. The Space Shuttle EMU is not worn during launch or reentry. So, not all Shuttle astronauts need an EMU.

Each Space Shuttle EMU is assembled from interchangeable parts. Various size arms, legs, and bodies are combined as needed to

■ SPACE SHUTTLE EMU SUIT



fit an astronaut for his or her flight. The variation in the sizes of available parts can be combined to create spacesuits capable of fitting something like 95% of the population. After each Space Shuttle mission, the EMUs are taken apart, cleaned, and stored. After several more flights, the suits are taken completely apart for more thorough maintenance.

Like the earlier spacesuits, the Space Shuttle EMU consists of multiple layers. Like the A7L, the inner layer of the Space Shuttle EMU consists of a liquid cooling garment. For comfort, this inner layer is made from nylon tricot. The pressure-retaining layer is made from urethane-coated nylon and an outer layer of Dacron that keeps this inner layer from ballooning out. Neoprene coated ripstop nylon is the next layer, and keeps the suit sealed in the event of a micrometeoroid strike. Additional protection from temperature extremes and micrometeoroid impacts comes from seven alternating layers of aluminized Mylar and Dacron scrim. The outermost layer protects the inner layers and consists of a mix of fibers (Nomex, Gortex, and Kevlar). Even with all these layers, the EMU is only 3/16-inch thick.

Instead of using zippers to seal the suit, the EMU is only split at the waist. The upper torso of the EMU consists of a fiberglass hard shell called the Hard Upper Torso, or HUT. There are bearing seals in the HUT where the arms, helmet, and lower torso attach. The Space Shuttle EMU PLSS is affixed directly to the HUT, so there are no external hoses like those on the Apollo spacesuits. There is no need for a pressure-retraining layer in the HUT; only the thermal and micrometeoroid protection cover the HUT. It only takes an astronaut 20 minutes to don the Space Shuttle EMU, and a majority of the work is done by the individual.

The Space Shuttle PLSS holds seven hours of oxygen, carbon dioxide scrubbing equipment (lithium hydroxide canisters), a warning system, batteries, water cooler, fan, and radio. A microcontroller monitors conditions of the EMU and provides audio and visual warnings to the astronaut. Perspiration and body odor are sucked out of the EMU near the hands and feet and are filtered out of the air stream within the PLSS. Anti-fog compound is still wiped on the inside of the helmet. At the base of the PLSS is a secondary oxygen pack that provides 30 minutes of emergency breathing should the PLSS fail. Between spacewalks, the PLSS is recharged inside the Space Shuttle airlock.

The Space Shuttle operates at 14.7 PSI of atmospheric pressure in a mixed oxygen and nitrogen atmosphere. The EMUs operate at about 4 PSI of pressure and at 100 percent oxygen. So, part of the process of donning an EMU is for the astronauts to pre-breathe pure oxygen while preparing for an EVA.

For comfort, a drink bag is placed inside the HUT. Astronauts can drink from the bag through a straw attached to the bag. The astronauts also wear an adult diaper. Gloves attach to the ends of the arms through a bearing seal (no zippers) and contain heaters to keep the astronaut's hands warm.

SPACESUITS OF THE INTERNATIONAL SPACE STATION

Currently, Russian and American spacesuits are carried onboard the ISS. Modifications being designed for the American suits will make them easier to fit the variety of astronauts and cosmonauts that will eventually visit the station. Currently, spacesuit technicians assemble a spacesuit for each astronaut making a space walk on the Space Shuttle. Because there will be no technicians onboard the ISS, it isn't practical, in the long run, to send new spacesuits up with each visiting

astronaut.

Therefore, work is being done to design sizing rings for the ISS spacesuits. The rings are designed to fit between suit joints, such as between the arms and gloves, and extend the length of spacesuit elements. Sizing rings are made from aluminum and come in several lengths. With sizing rings, astronauts can modify spacesuits to fit while they work on ISS.

THE NEW PLANETARY SUIT

We've seen some of the changes made in American spacesuits as they evolved from Project Mercury's emergency-only spacesuits to the Apollo and Space Shuttle working spacesuits. The new planetary suits will build on this history to create suits that are lighter in weight and easier to work in and maintain.

REDUCING BENDING EFFORT

To allow an astronaut to bend his or her arms without reducing the interior volume of the suit, rotating bearings will probably be added to planetary suits. So, instead of flexing the fabric in the arm of a planetary suit, an astronaut will instead rotate his or her arm up and down through the bearing surface in the shoulder. This reduces the degree of rotational freedom in the shoulders and "programs" the movements of the astronaut. However, they will easily learn how they must move their arms and they will grow accustomed to it.

Restraint layers (linknet) are being made from more advanced fibers than the spectra currently used in modern EMUs. By using stronger materials that stretch less in the linknet layer, a thinner linknet layer can be used. And the thinner this layer, the less torque required to bend the layer.

Some stretch in the planetary suit fabric can be desirable. In the right place, stretch can prevent the build-up of stress points in the suit. As a result, the fabric of the planetary suit in that location doesn't have to be as strong or as thick. Stretching also reduces the chances of material failure from over stressing.

REDUCING WEIGHT

To reduce planetary suit weight, ILC is replacing the old Space Shuttle EMU HUT with a soft upper torso made from fabric. Points on the suit where parts are connected together are being replaced with machined titanium. The titanium creates lighter weight attachment points with the same strength as the old steel swivels and brackets used in current spacesuits.

Aluminum has replaced steel as the material in the bearing rings that seal together elements of the suit. However, some bearings — like those in the shoulder — are being replaced with experimental graphite epoxy rings that save a pound of weight over the aluminum rings. Further weight savings may occur by using materials that provide multiple functions. As an example, a single layer of new material may be able to replace two layers, such as a pressure-retaining layer and a thermal layer.

So far, ILC has managed to reduce the weight of the planetary suit from the 107 pounds of the Space Shuttle EMU to just 65 pounds.

REDUCING SUIT MAINTENANCE

During the last of the Moon landings, Apollo astronauts performed maintenance on seals and zippers of their space suits. Maintenance on the planetary suits will be different. Instead of regularly applying lubricants to bearing surfaces, the bearings in these suits will be treated with low friction coatings.

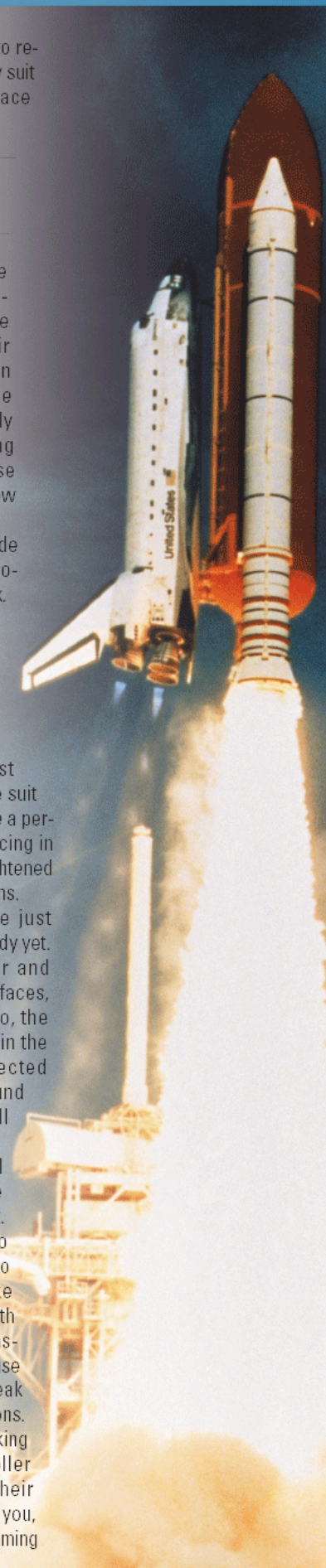
Planetary suits will be made ready for different sized astronauts quickly and with less work. The use of sizing rings and lacing allows astronauts to customize the fit of a planetary suit for themselves. Before joining parts like the waist and legs, the proper sized sizing rings are first snapped into the suit. Now the suit elements can be joined to make a perfectly fitting planetary suit. Lacing in the arms can be loosened or tightened to change the length of the arms.

The planetary suits are just experiments, so they're not ready yet. More tests, like the number and position of rotating bearing surfaces, still need to be finalized. Also, the ability of new materials used in the suits to stand up to the expected environmental conditions found on the Moon and Mars still needs to be tested.

Electronics and logic will certainly play a larger role in the operation of the planetary suit. Control switches sewn into the suit will allow astronauts to control suit functions like temperature and lighting. With embedded microcontrollers, astronauts may not have to even use switches; instead they may speak or gesture to enable suit functions. It sounds like NASA will be looking for those with microcontroller experience to help design their future planetary suits. If I were you, I'd begin designing and programming with microcontrollers now! ■

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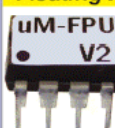
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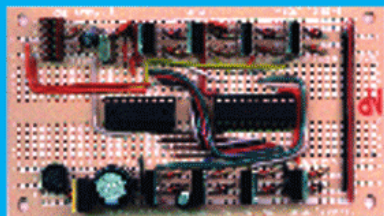
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receiver circuit board is shown. Figure 6 actually shows the transmitter circuit board. Sorry for the errors.

Andy LaTorre
Writer

>> WICK IS RIGHT?

In your October 2005 Stamp Applications article on the electronic candle, I am concerned about the Figure 2 schematic on page 15. It shows 220 microfarad 25 volt capacitors connected between ground and the outputs of a ULN2003 Darlington driver IC. When the output is off, the capacitors can charge up to the 12 volt power supply level. When the ULN2003 outputs turn on, the main things limiting the discharge current through it are: the capacitor ESR, the wiring inductance, and the on resistance of the ULN2003. The current could easily exceed the 600 milliamp peak rating of the device outputs. I would recommend that a 1/4 watt current limiting resistor of 20 ohms be added in series with each of the ULN2003 outputs to limit the current to within the manufacturer's specification. Other than that, it was a clever application of a handy Parallax product.

Robert Lacy

The reader is technically correct but in practice (and we've built a lot of these candles) we have experienced no problems — probably because the rating of the part is shown at 100% duty cycle and the instantaneous charge/discharge (depending on circuit) is too short to dissipate much energy through the ULN2803.

The actual error, however, that another reader pointed out is that I show the capacitor in the wrong position in the printed schematic. I have corrected that and posted the correction in our forums at <http://forums.parallax.com/forums/default.aspx?f=22&m=89937>

Jon Williams
Columnist, Stamp Applications

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Continued from page 36

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Signal Forge has released the first high-performance, digitally synthesized signal generator with an 800 MHz range, usable to 1 GHz, for under \$1000. The Signal Forge 800 (SF800) features a dedicated digital output with programmable voltage levels for testing digital systems and integrated circuits. It also provides an AC coupled and a differential output for testing a wide range of wireless and radio frequency devices. The SF800 produces both sine waves and square waves across a frequency range of 1 KHz to 1 GHz, in 1 Hz increments. The small size and low price point, compared with other signal generators of comparable performance, makes the SF800 attractive to design and test engineers, as well as field service engineers.

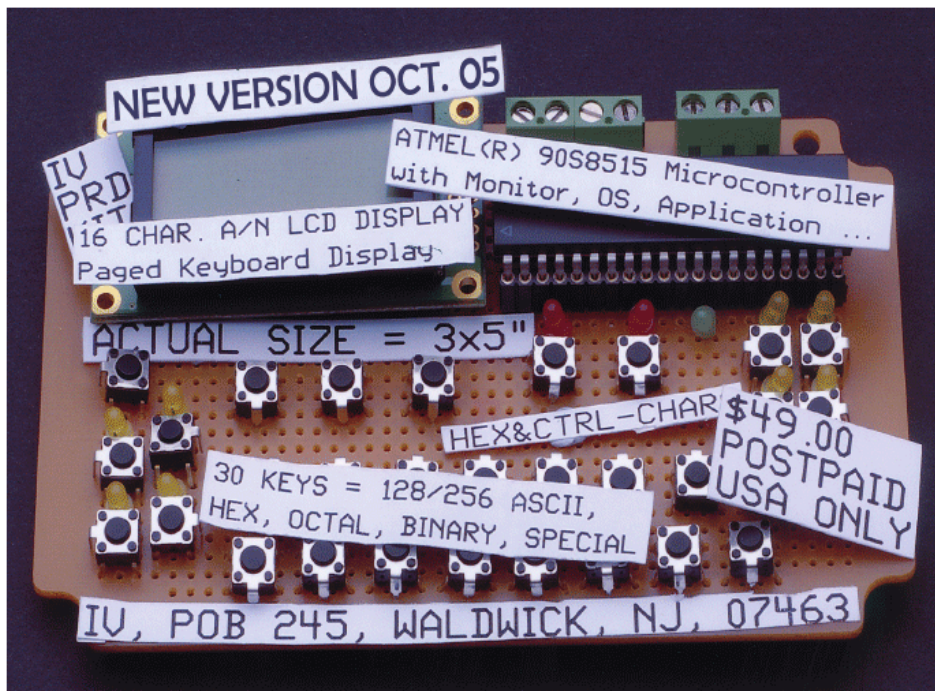
Unlike other signal generators, the SF800 incorporates a low-noise, temperature-compensated crystal oscillator (TCXO), ensuring a high level of precision and accuracy over a wide time span and temperature range. It also utilizes digitally synthesized signals and an embedded microprocessor which enable it to provide high quality signals, a rich feature set, and the easy to use Wave Manager software for setup and operation.

The SF800 helps engineering managers address problems they have been struggling with for years: shorter product design cycles, the increasing cost of test and development tools, and budget limitations. One way to reduce test time is to run several tests on systems simultaneously. Most high-performance signal generators are large and expensive making it difficult for most companies to do this. The SF800 solves this problem.

A wide frequency range with a 1 Hz resolution and the waveform modulation features make the SF800 suitable for applications such as: characterizing narrow band communication systems, the IF and RF section of receivers and subsystems, and selected mobile and telemetry bands. For example, the SF800 may be used to test

amplifiers for gain as well as for the 1 dB compression point, and for testing the third-order intercept point (IP3) of WLAN, ISM, and Bluetooth radio systems. Other applications include: design margin testing of digital ICs and circuit boards; data acquisition system testing and oscilloscope clock-

ing where a customized timebase is required for specific measurements; automotive electronics testing; determining the effect of oscillator drift on a circuit; examining the spectral response of circuits; FM CHIRP testing; and low cost manufacturing test. The Signal Forge 800 is priced at \$985. ■



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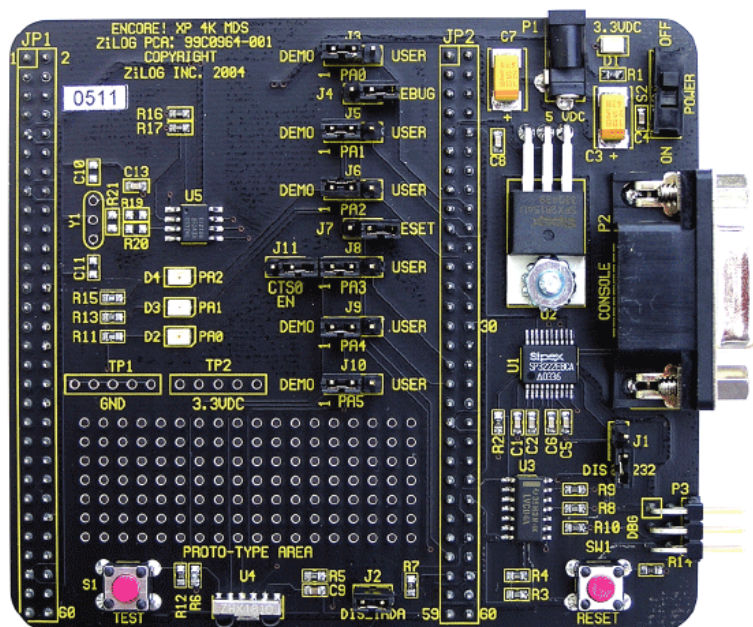
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THE ZILOG Z8Encore! XP MICROCONTROLLER

A FEW MONTHS ago, I received an email from info@zilog.com announcing a special offer of only \$9.95 for their new Z8 Encore! XP 4K Series Development Kit. Like any good (or helpless) electronics shopper, I cannot resist a bargain like that, and promptly ordered a few kits to play with (one for me and a couple for my teaching colleagues).



■ FIGURE 1. Z8 ENCORE! XP 4K SERIES DEVELOPMENT BOARD

A few days later, the kits came in the mail and I wasted no time opening one up.

Each Z8 Encore! XP 4K Series Development Kit comes with the following items:

- Z8 Encore! XP 4K Series Microcontroller
- Three LEDs
- RS-232 interface
- IrDA transceiver
- Two push buttons, RESET and TEST
- 5 VDC power connector
- On-chip debugger interface

- 8 MHz ceramic oscillator
- Header for ADC input
- Prototyping area
- External interface connectors
- 2.7-3.6 volt operating voltage with five volt-tolerant inputs

Figure 1 shows the development board. U5, the eight-pin SOIC located near the upper left corner, is the Z8 Encore! XP microcontroller. It is fascinating to see a complete microcontroller housed in an eight-pin SOIC. The device is also available in 20- and 28-pin packages.

The red TEST and RESET push buttons are located at the bottom.

■ FIGURE 2. PIN ASSIGNMENTS FOR THE EIGHT-PIN Z8 ENCORE! XP

VDD	1	8	VSS
PA0, T0IN, T0OUT, XIN, DBG	2	7	PA5, TXD0, T1OUT, ANA0, CINP, AMPOUT
PA1, T0OUT, XOUT, ANA3, VREF, CLKIN	3	6	PA4, RXD0, ANA1, CINN, AMPINN
PA2, RESET, DE0, T1OUT	4	5	PA3, CTS0, ANA2, COUT, AMPINP, T1IN

To the right of the RESET button is the six-pin connector for the SmartCable used to download code into the development board and control and monitor its operation. Located above the SmartCable connector is a nine-pin female RS232 serial communication connector. In the upper right corner, you can see the power switch and DC power connector.

Located below U5 are three LEDs (red, yellow, and green) and an on-board prototyping area suitable for interfacing small circuits. Below the prototyping area is the IrDA-compliant infrared transceiver. Numerous on-board jumpers enable and disable portions of the development board hardware, according to the function desired.

The Z8 Encore! XP microcontroller comes packed with these features:

- 20 MHz eZ8 CPU core, which yields 10 MIPS
- Enhanced instructions support 12-bit linear addressing of the Register File for improved performance, including BIT, BSWAP, BTJ, CPC, LDC, LDCI, LEA, MULT, and SRL
- Up to 4KB of Flash with in-circuit programming capability
- Up to 1KB of RAM and 128B of non-volatile data storage
- Up to eight-channel, 10-bit sigma-delta A/D converter
- On-chip temperature sensor, analog comparator, and transimpedance (current sense) amplifier
- Internal precision oscillator
- Crystal oscillator with three power settings and external RC network option
- Full-duplex nine-bit UART
- IrDA-compliant infrared encoder/decoders
- Two 16-bit timers with capture, compare, and PWM capability
- Watch-dog timer with internal RC oscillator
- Up to 25 I/O pins depending upon package
- Up to 18 interrupts with configurable priority
- On-chip debugger
- Voltage brown-out protection and Power-On Reset
- 2.7-3.6 volt operating voltage with five volt-tolerant inputs

That is quite a lot of hardware to pack into a microcontroller package. Figure 2 shows the pin assignments for the eight-pin SOIC package.

Note that all pins (except for power and ground) have multiple uses, with their functions determined via the program downloaded into the Z8 Encore! XP.

After taking a few minutes to install the ZDS II compiler tools and documentation, I was ready to set up the development system and plug its USB cable into my computer. The new USB device was detected and the drivers for the Xtools SmartCable interface were installed. I turned on power to the development board and the three on-board LEDs began flashing in sequence (red, yellow, green). Pressing the TEST button made them flash in the opposite order. So, everything was good to go.

Next, I launched the ZDS II compiler from Xtools and opened a project for the 4K development board. The project code compiled fine, but I was not able to download the code into the development board. In fact, the communication software could not even establish contact with the development board.

But this was my fault, for I had not yet looked through any of the documentation on the development board. I located the PDF associated with my development board and read through it. I learned that the development board has two modes of operation: USER and DEMO. The board is shipped with all on-board jumpers set up for DEMO mode.

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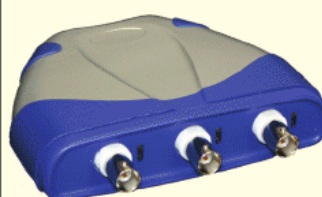
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Several jumpers need to be changed to allow USER-mode downloading of new programs into the XPs Flash memory. I changed the jumpers and successfully downloaded code to the board. I scolded myself for not looking more closely at the documentation before beginning, but old habits are hard to break. I like to look at the hardware first before going through "paperwork."

All of this activity took less than 15 minutes. With sample C-code already available, it will be very easy to begin developing my own application. In fact, if you do not want to reinvent the wheel, just look through the numerous application notes available, covering interfacing topics from stepper motors, LCD displays, and infrared, to pressure sensors, accelerometers, and RF communications.

Now that I have introduced you to the Z8 Encore! XP 4K Series Development Kit, how would you like to get one for free? Well, here's your chance, so pay attention! The ZiLOG Corporation has donated 10 kits that are to be given away to individuals selected by me, as part of a design contest. The rules for the design contest are as follows:

- ❶ Your design must involve interfacing an electronic device to the development kit. It could be as simple as adding a seven-segment display, or as complex as adding a 10baseT Ethernet controller.
- ❷ You must write original C software (or even assembly language) to control your design, using the ZDS II compiler.
- ❸ You must submit a proposed timeline of your development

cycle (design, construction, testing).

So what do you have to do to get a kit? Just send me a detailed proposal for your planned design, telling me exactly what you will do with the development kit. Once I look over all of the proposals, I will choose the 10 most interesting ones and announce the winners in a subsequent column. The deadline for submissions is Friday, December 16, 2005.

Next time, you will see what I chose to do with one of my Z8 Encore! XP development kits. ■

James Antonakos is a Professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College. With over 29 years of experience designing digital and analog circuitry and developing software, he is the author of numerous textbooks on microprocessors, programming, and micro-computer systems. You may reach him at antonakos_j@sunybroome.edu or visit his website at www.sunybroome.edu/~antonakos_j

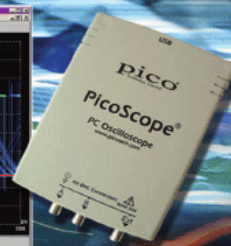
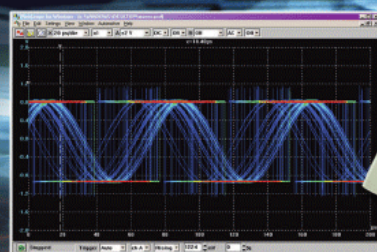
ACKNOWLEDGEMENTS

I would like to thank my associates at ZiLOG Corporation, Eric Wallentine and Mark Button, for their help securing the donated Z8 Encore! XP kits.

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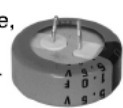
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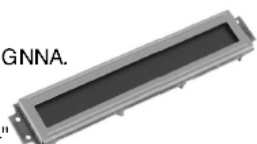
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STAMP APPLICATIONS

PUTTING THE SPOTLIGHT ON BASIC STAMP PROJECTS, HINTS & TIPS

LET THERE BE LEDs ... AGAIN

WE SEEM TO BE ON AN LED TREND HERE; last month faux candles, this month a digital display. Okay, perhaps it's just me, but I get the feeling that with the ever-increasing variety of LED options — size, shape, and color — there is renewed interest in LED control. I frequently find neat seven-segment displays at Tanners, and need a simple way to control them when using a BASIC Stamp. I found one and am going to share it with you.

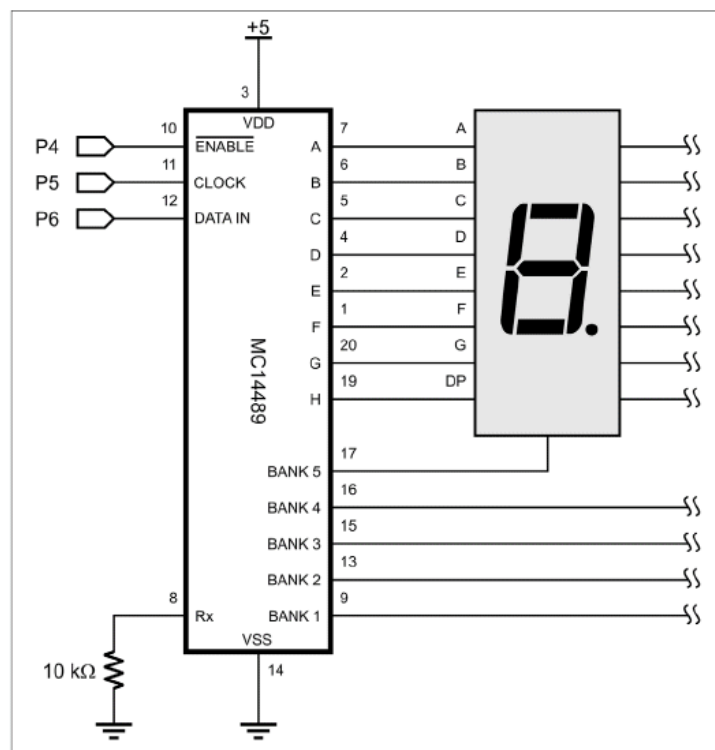
The control of seven-segment LED displays can be tricky, and is downright impractical to do in high-level BASIC Stamp code — the best thing to do is enlist a “helper” chip. In the recent past, we created our own multiplexer with the SX micro, and both Scott Edwards and I have written about the MAX7219. Well, not everybody has SX tools, and, at \$11 each, the MAX7219 is not cheap. Is there an alternative? As a matter of fact, there is.

The device we'll work with this month is the Motorola MC14489 display multiplexer. It's certainly cheaper than the MAX7219 — the average online price is around four bucks. That said, it doesn't do quite as much (only five digits versus eight for the MAX7219) and it does have a couple quirks that take a bit of time to get used to. I've worked through those quirks and hope that I can steer you around my initial frustrations with this chip.

GIMME THREE PINS

Connection to the MC14489 is simple, taking just three I/O pins (Clock, Data In, and Enable). The *Clock* and *Data In* lines can be shared, and the MC14489 has a *Data Out* connection to provide for daisy chaining if we want to control more than five digits. With the clock line we're going to use **SHIFTOUT** to send data.

The only other component required is a 10K resistor to control display brightness. You could actually drop a pot in place of the 10K if you want brightness control, and if you're really ambitious, you could use a CdS photocell (not alone, though) to automatically adjust brightness for changes in ambient light. Let's keep things simple, shall we? A 10K resistor on the MC14489.Rx pin 8 works fine. Figure 1 shows the connections for using the MC14489 with up to five seven-segment, common-cathode displays. If you want to try this circuit on the PDB, don't worry about the 470-ohm resistors that are inline with the seven-segment displays; the LEDs are very bright and work just fine with the circuit in Figure 1.



■ FIGURE 1: MC14489 CONNECTION

Now, if you want to jump into the MC14489 quickly and can live with four digits, you have a ready-made option: the SLED4C Serial LED display from Reynolds Electronics. At 29 bucks it's a tad pricey, but it's nicely built and very convenient — it has four bright red digits (0.4-inch tall) with decimal points, a colon, and a third annunciator LED that can be used as you see fit. Figure 2 shows the SLED4C and the connectors that are included. Note that I put the BS2p module in the picture to give you an idea of the module's size — *it is not included with the SLED4C, so don't ask Bruce for it!*

What I do like about the SLED4C is that it has mounting holes that make it easy to install into a permanent project; in fact, we did that at Parallax. One of my new colleagues, Chris Savage, was asked by our production group to make a solder-pot controller. Chris used our thermocouple kit, a rotary encoder, and the SLED4C to make the controller. At the time, he hadn't actually worked with the MC14489 and asked me if I knew anything about it. Well, I had just written an update to StampWorks that included the MC14489, so I was able to show Chris the ropes very quickly with the SLED4C. In the end, we have a nice new solder-pot controller in our shop.

What I really liked about Chris' project was the use of the rotary encoder to enter the temperature set point. I've used a rotary encoder before, but not with a BASIC Stamp. My pal Scott wrote about using rotary encoders with the BS1 about 10 years ago (*Yikes, this column has been around a while ...*), so we'll just adapt that strategy for our

program. For details on encoder use, be sure to download column #8 (October 1995) from Parallax or from the *Nuts & Volts* website (www.nutsvolts.com) — that way we can focus on the MC14489.

LOCK IT UP

I've been asked a couple of times about creating a digital lock, but wasn't really sure what to do it with — until I saw Chris' use of a rotary encoder on the solder-pot project. So, what we're going to do this month is create a digital version of the old combination lock. Figure 3 shows the connection for the encoder and a push button (we'll use it to select our digit), and Figure 4 shows the connections to the SLED4C display.

In Figure 2, you'll see two headers that are included with the SLED4C, which let you decide how you're going to mount the unit. I soldered in the right-angle header so I could pop it into a breadboard, but if you're going to mount the display in a tight space, you may want to use the straight header (solder it with the long pins facing the back side of the display).

THE MC14489

Before we get into the lock code, let's talk about the MC14489. As I previously stated, it's pretty easy to use but does have a couple of quirks. The key to succeeding with the MC14489 is understanding those quirks. Communication to the MC14489 comes in the form of two packets: we either send a one-byte configuration value or six nibbles that control the digits of the display (the sixth nibble handles display brightness and the decimal point position).

Quirk number one is that we can only send a nibble to each digit. Initially, this seems like no big deal — until we want to do a custom display that doesn't involve a standard number or letter that one might see on a seven-segment LED. Since each digit gets only four bits, when we enter what is called "no decode" mode, we only have control of segments A-D, and segments E-G get disabled in this mode.

Before I forget, let's discuss the display modes. Hex decode displays digits, 0-F, based on the value of what's sent to the bank register. Special decode displays other letters and characters — things like "P" or an equal sign. No decode mode is just that — we have control of the individual outputs that control segments A-D.

Quirk number two is that the display configuration is packed into one byte, so we don't have absolute control over every digit for every possible mode. Table 1 shows the structure of the configuration byte.

Notice how banks 1-3 are grouped together (using bit 6), and banks 4 and 5 are grouped together (using bit 7)? The bottom line is that any digit can be set to hex decode mode by making its control bit (1-5) zero; any digit within the same group can be in no decode or special decode, but within the same group, you cannot mix no decode and special decode modes.

I know that's a mouthful. Once you understand that you can't mix no decode and special decode modes in the same group, it's easier to deal with the MC14489. Again, communicating with the chip is quite

easy, and can be handled with two subroutines.

```
Set_Cfg:
  Enable = 0
  SHIFTOUT DataIO, Clock, MSBFIRST, [config]
  Enable = 1
  RETURN

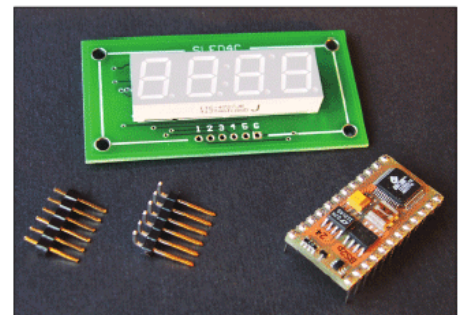
Set_Banks:
  Enable = 0
  SHIFTOUT DataIO, Clock, MSBFIRST,

    [dpCtrl\4,
     bank5\4,
     bank4\4,
     bank3\4,
     bank2\4,
     bank1\4]

  Enable = 1
  RETURN
```

As you can see, the Enable input of the MC14489 is active-low, so communication with the chip starts by bringing this pin low. Then we'll send (via **SHIFTOUT**) either one byte or six nibbles. The MC14489 will automatically put everything in the right place based on how many bits are sent. Note that we are using individual nibbles for bank control, so we have to use \4 in **SHIFTOUT** to specify four bits for each variable (the default bit count is eight).

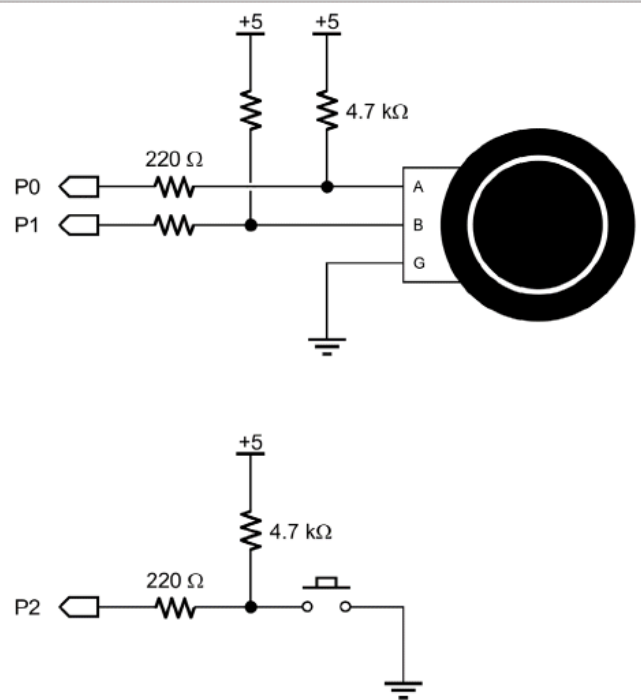
■ FIGURE 2: SLED4C MODULE



By using individual nibbles and this subroutine, we get the most flexibility for our programs.

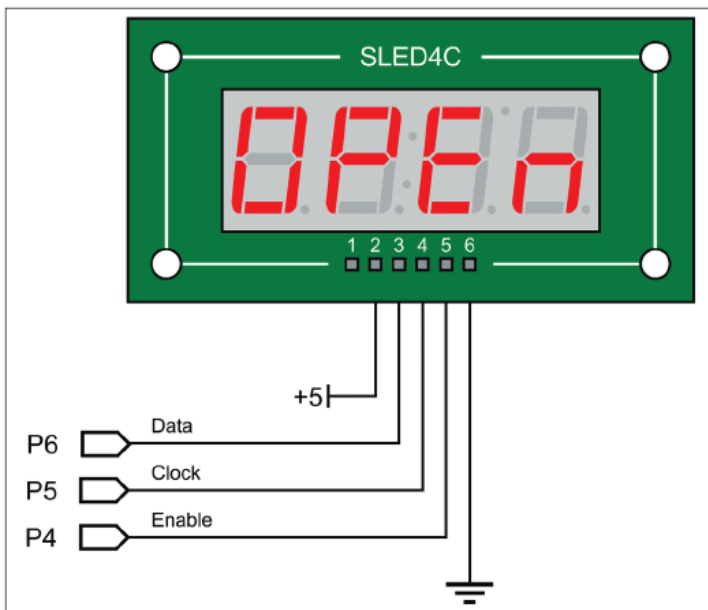
Let's have a look at the lock code. Structurally, it's pretty simple. What we want to do is to display the current dial value as the encoder is turned. When

■ FIGURE 3: ENCODER CONNECTION



► TABLE 1: STRUCTURE OF THE CONFIGURATION BYTE

Bit0	- Display control; 0 = off, 1 = on
Bit1	- Bank 1 mode; 0 = Hex decode, 1 = Set by Bit6
Bit2	- Bank 2 mode; 0 = Hex decode, 1 = Set by Bit6
Bit3	- Bank 3 mode; 0 = Hex decode, 1 = Set by Bit6
Bit4	- Bank 4 mode; 0 = Hex decode, 1 = Set by Bit7
Bit5	- Bank 5 mode; 0 = Hex decode, 1 = Set by Bit7
Bit6	- 0 = No decode, 1 = Special decode (for Banks 1-3)
Bit7	- 0 = No decode, 1 = Special decode (for Banks 4-5)



■ FIGURE 4: SLED4C CONNECTIONS

the button is pressed (I have an encoder with a built-in button, which is very convenient for this application), the value in the display will be compared against the combination value for the current state. If they match, the state value is incremented; otherwise, the state is reset to zero (locked). When the state counter hits three, the lock is opened (an electric solenoid, for example, could be energized) and "OPEn" is displayed and flashed. At this point, the program will wait for the encoder to be

Config.7	Config.6						
5	4	3	2	1			
H	H	H	H	H	%xx000001	e.g., "72562", "A2b4E"	
H	H	H	S	H	%x1000101	e.g., "123°F"	
S	H	H	S	H	%11100101	e.g., "-25°C"	
S	H	S	S	S	%11101111	e.g., "HELP "	
N	H	H	H	N	%00100011	e.g., " OFF "	
S	H	S	S	S	%11101111	e.g., " On "	
H	S	H	S	S	%11010111	e.g., "OPEn "	
H	H	H	H	N	%x0000011	e.g., "123°F", "12:34"	
S	H	H	H	N	%10100011	e.g., "-25°C"	
S	H	S	S	S	%11101111	e.g., "HELP"	
H	H	H	N	N	%x0000111	e.g., "OFF "	
S	H	S	S	S	%11101111	e.g., " On "	
H	S	H	S	S	%11010111	e.g., "OPEn"	

turned again, and when this happens the lock will reenergize.

First things first — how do we set the lock code? Keeping things easy, we can embed the combination into a **DATA** statement.

Combo DATA 07, 25, 62

This works well for a couple of reasons: we can read the current combo value using the state variable as an index, and being stored in EEPROM, we could update the program later to allow the combination to be set externally (without reprogramming the BASIC Stamp). Note that this program is using two digits for the dial value, so we have to keep the combination numbers under 100.

The first part of the program initializes everything. Normally, not much happens in this section, but since that's not the case here, we'll go through it.

```
Reset:
  LOW Solenoid
  HIGH Enable
  encOld = Encoder & %0011
  state = Locked
  GOSUB Update_Display
```

We start by engaging the lock, making the Enable pin an output and high to disable communication to the SLED4C, and then we read the current encoder position so movement can be detected later. The lock state variable gets initialized (note the alias "Locked" that makes the program easier to understand), and finally, we update the SLED4C display.

The display update is state dependent and really just a router to the code that handles the display for entering numbers or showing "OPEn."

```
Update_Display:
  IF (state < Open) THEN
    GOTO Show_Dial
  ELSE
    GOTO Show_Open
  ENDIF
```

Let's look at the module we'll use the most. It's called Show_Dial and it does just that: it shows the current dial position, 0 to 99. Just to dress up the display, I centered the value in the middle of the display and surrounded it by underline characters (more on this in a bit).

```
Show_Dial:
  dpCtrl = %1000
  bank5 = ULine
  bank4 = dial DIG 1
  bank3 = dial DIG 0
  bank2 = ULine
  #IF (ShowState = 1) #THEN
    ' update state LEDs (colon dots)
    LOOKUP state, [%0000, %0001, %0011], bank1
  #ELSE
    bank1 = %0000
  #ENDIF
  display = IsOff
  GOSUB Set_Cfg
  GOSUB Set_Banks
  config = %00100111
  GOSUB Set_Cfg
  RETURN
```

The subroutine starts by updating the values of the bank control registers. In banks 5 and 2, we will show an underline character; this value comes from a program constant. The DIG operator gets used to pull

■ FIGURE 5: CONFIGURATION VALUES

the tens and ones digits from the dial value for banks 4 and 3.

There is a conditional constant in the program called *ShowState* that is used for testing. Its purpose is to show the current state of the lock code using the LEDs that form the colon in the SLED4C display. These LEDs can be individually controlled and are connected to bank 1 bits zero and one. If *ShowState* is set to one, then **LOOKUP** gets used to enable the correct number of LEDs for the current state. Otherwise, they are all blanked (for normal operational mode).

Now that the register variables are updated, we will turn the display off. Why? Well, we don't have to, but what can happen is a bit of "ghosting" that just doesn't look very nice. Even with a stock BS2, the blanking and update happens so fast that we can't see the blanking period.

After the new values are sent to the bank control registers, we update the configuration register. Bit 0 will always be set to enable the display. Bits 1, 2, and 5 are set to one, which means they will either be in no decode or special decode mode, which depends on bits 6 and 7. In this case, both are set to zero, so banks 1, 2, and 5 will be in no decode mode (remember that this mode gives us control over segments A-D only). Banks 3 and 4 are set to hex mode (0 in their configuration control bits), so we can display the dial digits.

Here's where that configuration byte quirk affected the program. Initially, I wanted the display to show "-XX-" (dash-digit-digit-dash), but when using the SLED4C, the bank 1 digit needs to be set to no decode mode to enable control of the colon LEDs. This forces the use of no decode mode for banks 2 and 5 as well (so they match), and in that mode we cannot control segment G (which would make the dash we wanted). So, we live with the underline.

At this point, the display should show "_00_" — until we turn the dial. Here's the code that handles the encode input.

```
Main:
DO WHILE (NumSelect = NotPressed)
  encNew = Encoder & %0011
  IF (encNew <> encOld) THEN
    dial = dial + 1 + (98 * (encA ^ encB)) // 100
    encOld = encNew
    GOSUB Update_Display
  ENDIF
LOOP

DO : LOOP WHILE (NumSelect = Pressed)
```

As you can see, we're simply monitoring the encoder while the button is not pressed. If it moves, the dial value gets updated and we save the new encoder position for the next check. The only tricky bit here is this:

```
dial = dial + 1 + 98 * (encA ^ encB) // 100
```

You may remember from all of my discussions about the modulus operator (//) that, if you want to increment a value between 0 and 99 with rollover, you can do this:

```
value = value + 1 // 100
```

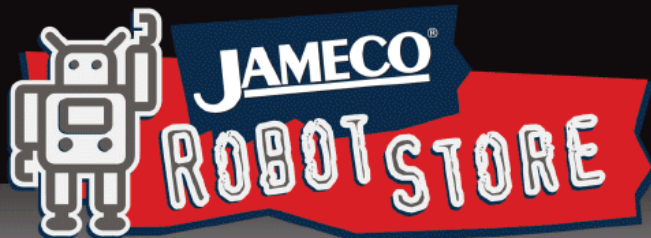
And, if you want to decrement a value between 99 and 0 with rollover, you can do it like this:

```
value = value + 99 // 100
```

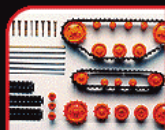
If you look closely at the program, we've cleverly incorporated these two lines of code — how it operates is based on the encoder test. By XORing the encoder bits, we can determine direction, so that

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what this code does is multiply the direction result (0 or 1) by 98 and add that into the rest of the equation. As you can see, we'll end up adding one (clockwise) or 99 (counter-clockwise) when the encoder moves. By using modulus, we're able to keep the dial value within our specified range with rollover for clockwise rotation and roll-under with counter-clockwise rotation. This is a neat trick.

When the button does get pressed, the encoder test loop will get skipped. A small inline **DO-LOOP** is used to force the release of the button before moving on — this keeps the program from accidentally accepting the current dial value more than once when that is not the intention. After the button is released, we can test the dial input against the current combination value.

```
Check_Digit:
  READ (Combo + state), testVal
  IF (dial = testVal) THEN
    state = state + 1 // 4
  ELSE
    state = Locked
  ENDIF
  GOSUB Update_Display
```

This is pretty easy. We start by reading the current state combination value from EEPROM, and comparing it to the dial value. If they match, the state value gets incremented; otherwise, we set the state back to *Locked*.

The last thing to do is check the current state to see if the lock is to be opened. First, let's look at the code that displays "OPEN" on the SLED4C:

```
Show_Open:
  dpCtrl = %1000
  bank5 = Ltr_O
  bank4 = Ltr_P
  bank3 = Ltr_E
  bank2 = Ltr_n
  bank1 = $0000
  display = IsOff
  GOSUB Set_Cfg
  GOSUB Set_Banks
  config = %11010111
  GOSUB Set_Cfg
  RETURN
```

By now, this should make sense. Note that we've switched from no decode to special decode mode for banks 4 ("P"), 2 ("n"), and 1 (blank colon). And, finally, here's the code that activates the lock when we've reached the open state:

```
Check_Activation:
  IF (state = Open) THEN
    Solenoid = IsOn
    DO
      PAUSE 100
      display = display ^ 1
      GOSUB Set_Cfg
      encNew = Encoder & %0011
      LOOP UNTIL (encNew <> encOld)
      GOTO Reset
    ENDIF
    GOTO Main
```

Of course, we start by opening the physical lock with solenoid activation, and then we make sure that we know the lock is open by flashing this display. This is easily accomplished by toggling the display control bit (config.BIT0), and we can do this using XOR (^). Through each iteration of the loop, we check the current encoder inputs so that we can reset the lock when the encode moves. Well, that's all there is to it. True, it's pretty simple, but I think this code is useful and I will be adding more encoders to my projects. Just remember that the BASIC Stamp is not as fast as the SX, so you can "over spin" the encoder and get bogus values. That said, I found the program to be quite responsive with normal operation of the encoder.

I hope this helps you get going with the MC14489. It may not be perfect, but it's inexpensive and easily connects to the BASIC Stamp to give us seven-segment LED control. Remember that the key is the configuration register — when you understand how it works, the rest is pretty simple.

And just to help you in that regard, I made a chart that shows different configuration values for several useful display setups (Figure 5). The bottom half of this chart is specifically for the SLED4C that we used in this project, hence the shaded bank 1 box. You'll also note that hex mode is not ever used in this position.

Happy Thanksgiving to you and yours, and until next time, Happy Stamping! ■

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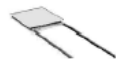
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>>> QUESTIONS

I have a small problem trying to figure out how to make an A & B switch that can be connected to two computers.

I want my 5 & 1 speakers to be shared by both computers without having to disconnect them. For instance, when I want to hear audio from computer A, simply switch to A, etc.

Can someone provide a schematic that I could build from?

#11051 ■ F. R. Lazzu, via Internet

I have a Proview Technology color-monitor model 986 N. It is so well made, I hate to throw it away. To repair it I need two ICs — TDA 9536 video amplifier and TDA 9210 video pre-amp. NTE does not show substitutes. I have found two places that have these chips, but they have \$100 minimum orders. Does anyone know where I could get these chips at a reasonable price?

#11052 ■ Harold Eddy, Dixon, IL

I'm trying to improve WWVB reception here in Southern New Hampshire. The problem seems to be that the internal antenna (tuned ferrite rod) in the clock can't be oriented properly where I want the clock located. I'm thinking along the lines of a larger, 0.5 X 7.5 inches, tuned ferrite rod feeding a FET op-amp, maybe

an LF356. Drive a small audio transformer with the op-amp output to provide something like an eight ohm output to feed a twisted pair feedline. At the clock, use another transformer and connect it to an added winding on the original clock antenna rod. This would allow placing the antenna in correct orientation, as well as allow selection of a better antenna location. With the carrier at 60 kHz, it would seem that audio components could be used. I've checked the transformer — a RadioShack 273-1380 (1K ohm to 8 ohm) — and it seems useful at 60 kHz. My question is, will something like this work, or is there something better? Thanks for any help or ideas.

#11053 ■ Don Pomeroy, via Internet

Does anyone have a simple circuit to test capacitors in circuit?

#11054 ■ Harold Eddy, Dixon, IL

I'm looking for a way to temporarily turn off an aquarium water pump during the feeding of my fish. I do this manually now by pulling the plug, but usually forget to plug the pump back in after feeding.

I need a circuit where the AC water pump (rated at 120VAC@40W) can turn off for about 10 minutes, then turn back on again automatically. Ideally, I'd like a momentary switch that when pushed, would turn the pump off for about 10 minutes. Accuracy is not critical. I was think-

ing of using a relay with NC contacts and perhaps a battery-powered 555 circuit, but do not know how to design this.
#11055 ■ Joe Jaworski, Asheville, NC

I bought (via eBay) a transistor diode tester model 219Z. This, I take, was used by the Navy a few years back. It was made by Sierra Electronics Corp., a division of Philco Corporation of Menlo Park, CA. I need a circuit that I can build instead of using batteries. Also, I could use directions or a book on how this thing operates. Any information would be greatly appreciated.

#11056 ■ Fred Stieghorst, Weslaco, TX

I have an old Gateway Profile 2 all-in-one computer and would like to use the monitor for a video screen. How can I go about finding the pinout for the monitor connection to the computer? Or better yet, how can I convert to a video screen? I have already figured out the power supply pinouts, so these I do not need.

#11057 ■ Rick Simard, via Internet

I am using an Apple Macintosh CRT Studio monitor coupled to a desktop PC. It is the model with a 17-inch Sony Trinitron tube and is themed in the Mac "blueberry" case.

There is some "squiggle" throughout the presentation on the CRT face. By this, I mean a kind of subtle wavy action in the picture appearing to run vertically. It is most noticeable with text but can be detected in any kind of graphic along the borders of a given object. From a distance of about 18 inches, it is not very perceptible, but gets more so within about 12 inches from the CRT's face. I have checked other monitors like this at the public library and none seem to exhibit this problem.

I have consulted *Troubleshooting and Repairing Computer Monitors* by Stephen J. Bigelow. The closest I can deduce from consulting this publication is the capacitors in one of the power supplies are aging and will need replacement. I was considering opening the monitor's case and "shotgun" replace all large capacitors in sight, but this will probably be a fool's errand.

Another possibility mentioned in the book is the shielding around the video cable may be nicked or kinked, but the cable appears intact. Can anyone offer some other ideas or a better rationale for isolating the problem?

#11058 ■ Ron Schild, Saratoga, CA

I have a neon light power transformer. Input is 120V, output is 7,500V @ 30mA. The output is powering an ozone generator that I built to help keep the smell of my hockey gear at bay. I need help limiting the power to the ozone generator. To vary the power output, do I place the limiter before or after the transformer (if before, would reducing the power shorten the transformers lifespan)? How do I go about adding a dial to limit the power to the ozone generator?

Background: My ozone generator is simple. A small glass jar with aluminum foil at the bottom of it with the high power transformer lead connected to it. The bottom of the jar is also covered with the foil. The ground lead is connected to it. The whole thing sits inside of another larger glass jar (for safety/insulation). A small fan circulates the air at the top. My transformer is connected to an egg timer to turn it off after x minutes. Any additional info on how this thing works would also be a welcomed plus!!! **Note:** In case any of your readers want to create one of these, I cover the metal parts of my hockey gear with WD-40 because O₃ likes to eat metal for breakfast.

#11059 ■ Steve Flanders
Lake Monticello, VA

>>>> ANSWERS

[#06053 - June 2005]

I am searching for an electronic simulation package that can account for the self-heating property of semiconductors. Given a user specified ambient temperature and the thermal resistance as a constant, the simulation would not only adjust the bias conditions (V and I) due to the rise in junction temp, but it would also tell the final junction temp.

Mr. Larsen asked for an electronic

simulation package to account for self-heating in semiconductors. At the risk of referring readers of your excellent publication to a sister pub, Cyril Bateman wrote a four-part article starting in the October 2004 issue of *Electronics World* in which he describes his successful attempt to include thermal effects in power MOSFETs. The articles describe how he simulated a MOSFET in Spice and then verified the model.

■ Sam Finklea, via Internet

[#08052 - August 2005]

How does the LNB on a satellite receiver dish work? I know that LNB stands for "Low Noise Block" converter.

Describing all the functions of an LNB and how it came to exist could easily turn into an article of its own. But I will try and give a condensed version of what an LNB is and why it does what it does.

As you stated, an LNB is a Low Noise Block converter. I will stick with the home consumer C-Band and Ku-Band type LNB that you will find on television systems and most people are familiar with. C-Band dishes are the "big dish" systems. Some also include a Ku-Band LNB within the system. The most common LNB is the Ku-Band type that you see on the mini dishes from companies like Dish Network and DirecTV. The LNB portion on all work more or less the same. The LNB has a small probe type antenna inside it that does the actual receiving of the electromagnetic waves from the satellite. The feedhorn and dish itself are all used to focus more of the RF energy into the LNB. On a big dish system, the LNBs and the feedhorn are separate devices. The true "correct" name for the devices found on the mini dish systems should be LNBF for Low Noise Block Converter Feedhorn. But most simply call this an LNB.

The signals coming from the downlink of the satellite are as follows:

C-Band	3,700 to 4200 MHz
Ku-Band	11,700 to 12700 MHz

(These are the "common" frequencies and can vary slightly from satellite to satellite design.)

As you can see, the above signals are in the microwave range. They are also extremely weak. To transmit these frequencies from the dish to the receiver point would require expensive and complex arrangement of waveguide and hard line coaxial type cables. To avoid this, a clever trick was performed on the down linked signals.

In order to understand an LNB's function, you must also understand the physics of signals. When two signals are mixed together, they form a SUM and DIFFERENCE of the two signals. This is something that goes on in 99.9% of all AM, FM, and TV sets in use today. The incoming radio wave is mixed with a signal inside the receiver (called the local oscillator). This forms a SUM and DIFFERENCE of the received signal and the local signal. The difference of these two is called the INTERMEDIATE FREQUENCY. This intermediate frequency is what is processed by the detector circuits. Any variance in amplitude or frequency of the received signal is mimicked in the intermediate frequency signal.

In the case of satellite signals, the incoming microwave frequencies are first amplified. Since the signals are extremely weak, a low noise (electrically) amplifier is used. This is the LN or Low Noise of the LNB. Just a quick word about the noise figures found on

LNBs: In the case of C-Band LNBs, it is common to give the noise figure in Degrees Kelvin. For the Ku LNBs, the figure is given in decibels. In both cases, the lower the number, the better the LNB. In the early days of satellite, the Low Noise Amplifier (LNA) and the Block Converter were actually two separate parts. The two were then combined into one. The Block converter employs an oscillator to mix with the incoming, amplified signal and shift it to a frequency range where it could be transmitted with cheaper cable. The common Local Oscillator frequencies used with consumer satellite systems are 5,150 MHz for C-Band and 10,750 MHz for Ku band. Doing a little math on the downlink frequencies and local oscillator frequencies, you will see that the mixing of the C-band signals results in a "difference" range of 1,450 MHz to 950 MHz or the commonly accepted range of 950 to 1,450 MHz.

Doing the same for the Ku signals and the Ku Local Oscillator frequency reveals a range of 950 MHz to 2,000 MHz. This new set of frequencies can easily be transmitted over high quality RG6 coaxial cable. This is a standard cable type found in mass production for cable TV and over the air television antenna systems. Note with the C-Band system that the Local Oscillator frequency is HIGHER than the received

frequency (as is common in most radio receivers). In the Ku-Band, the local oscillator frequency is lower than the received frequency. You still get the proper "difference" signal but the band is inverted on the C-band system receiver.

■ Tim Naami, Poplar Grove, IL

[#08053 - August 2005]

I need to assemble a device which will record time-of-day in 24-hour format for events, as follows: a person sees an event, and pushes a button; he sees another event, and pushes another (or the same?) button. Later, he can retrieve the event times (capability for up to five events will be needed) and reset the device for use next time. It would be used in a 12-volt vehicle.

#1 Recently, I started writing routines to connect a serial clock to the PIC. When I saw your request, it occurred to me my project only needs buttons and more programming to make exactly what you want.

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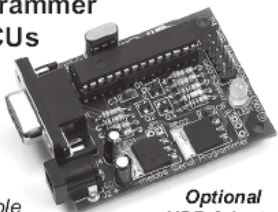
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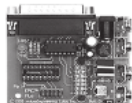
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Two buttons mounted below the display control setting the clock, triggering an 'event save', displaying and erasing the saved data. As the menu is accessed, the button definitions are printed on line 2, above each button.

If you would like more information, I can be reached at dhewett@cpol.net

■ Dennis Hewett, Frontenac, KS

#2 May I suggest a laptop computer? It has a built-in 24 hour clock and can record date, as well as time. You can pick up a used laptop at a yard sale for \$5 or \$10 that will do the job. There is a GWBASIC program that runs in DOS to record date, time, and comments. You can download GWBASIC from my website: www.geocities.com/russlk You may want to find someone to write a more elegant program, but this one illustrates what can be done.

■ Russell Kincaid, Milford, NH

#3 A very easy, off-the-shelf solution

might be a PDA or "palm-top" computer. It would have the added advantages of storing a long list of timestamps, and even allowing easy downloading into a computer. It would also allow relatively easy addition of other features such as recording the nature, identity, etc., of the event.

■ Richard Crowley, Hillsboro, OR

[#09051 - September 2005]

I need to take an input of a standard NTSC base band video signal and clean up glitches. I have a client with several amusement rides that use wireless transmitters to send video of the passengers to be recorded to a VCR. During certain portions of the ride, we get some signal drop out, usually a fraction of a second.

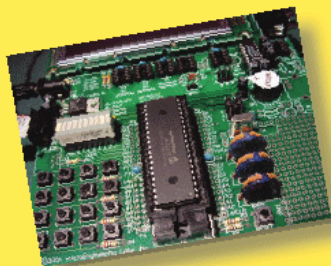
#1 Your best bet would be to correct the reason for the dropouts rather than attempt to store and then re-insert corrected video into the final recording. It

sounds like you're using a wireless link camera, so moving, replacing, or modifying the transmit and/or receive antennas or their locations would be the first thing to try. Storing and re-inserting stored video into your video stream is a complex and expensive process.

■ M. Byrnes, Fairfax, VA

#2 What is needed is a Time Base Corrector. The wireless transmitter to the VCR is losing its carrier which, in turn, causes a sync break on the VCR. Most consumer VCRs, and even many professional VCRs, do not have built-in TBCs. The TBC will basically keep the sync signal stable while the input video signal is unstable. Some better TBCs have frame-store buffers in them, so worse-case scenario is that when the wireless transmitted image is interrupted, the video freezes for a second or so until the video is stable again.

■ Kris Hain, Muskegon, MI



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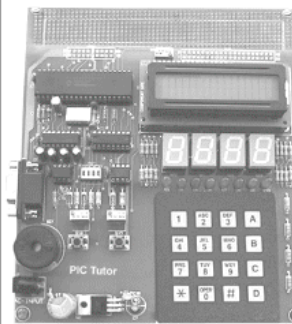
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[#09056 - September 2005]

I need some help in locating a horizontal output transistor to repair a Dell monitor, model D1626HT. I need a transistor #K1120 or cross reference replacement number. So far, everything I've tried has failed.

#1 The K1120 transistor is almost certainly a 2SK1120. The datasheet shows that as an N-channel MOSFET rated at 8 amps, 1,000 Vdss, 150 watts, and 1.5 ohms Rds.

Digi-Key part number 497-3255-5ND — an STW11NK100Z — looks like a suitable replacement at 1,000 Vdss, 8.3 amps, 230 watts, and 1.1 ohms Rds.

■ *Ed Schick, Harrison, NY*

#2 Horizontal output transistor 2SK1120 is available from Newark Electronics, Part #38C0182, \$4.53.

Before powering up, check for bad connections, check for bad caps in the driver section and power supply, and check the regulator section that supplies the flyback. Deflection B+ varies depending on display mode.

■ *Reed Adams, via Internet*

#3 A quick web search shows that the part you are looking for is Q909 which is a 2SK1120 MOSFET used as the high voltage output transistor. You can find Toshiba's datasheet on the part at: www.semicon.toshiba.co.jp/td/en/Transistor/Power_MOS_FET/en_20040726_2SK1120_datasheet.pdf

The schematic for the Dell D1626HT monitor is available for free download at: www.eserviceinfo.com/download.php?fileid=7887

You may need to follow the links to uncompress the PDF document from a type .RAR format.

■ *Barry Cole, Camas, WA*

#4 A couple of ideas as to your problem:

1): The part you need is a 2SK1120.

2): You say all replacements have failed.

Is this saying they failed instantly and then tested bad or they just won't work?

3): In a lot of makes, an OEM or original part is needed to work properly. You can get 2SK1120 from many sources including MCM Electronics

4): When the HOT blows out, you must check A): power supply volts at the collector, B): horizontal drive to the base of the HOT, C): the emitter resistor

Always check the Drive Signal and replace the drive transistor when the HOT Blows ... it usually takes it out with it.

You can get the schematic for your monitor here: http://fileshare.eshop.bg/downloadsm/7887/dell_D1626HT%20chassis%20N3.html

■ *Bruce Bubello, Wayne, NJ*

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The event will be rescheduled for 2006. Individuals and teams interested in competing should drop us an email to get on the competitors list for updates and info regarding the competition. The entry deadline will remain open for now. Don't send money or the entry form yet, just email to let us know you're interested and we'll keep you posted on what to do next and when to do it.

Hey, look on the bright side, not only do you *STILL* have time to enter, you have even *MORE* time to design and build your exosuit! So, there's no excuse now *NOT* to compete! This is a hard competition and certainly one worth participating in. If it were easy, everyone would be doing it. This is your chance to stand apart from the crowd and flex your engineering and bot-building muscles. So, hook up with your friends, fellow engineers, classmates, geeksquad, gearheads, whoever, and form a team. No need to go it alone!

If you haven't already done so, check out the new rule set and event changes and start scribbling out your preliminary design. There's no time to lose! **Send an email to tetsujin@servomagazine.com** with your name and email address and we'll make sure you get all the latest info and news.



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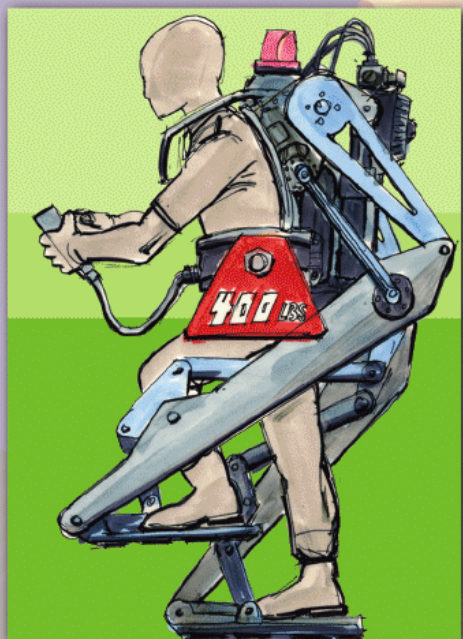
Weightlifting. Ascend stairs in your suit to the lifting platform and lift a load of from 100 to 1,000 lbs* from a squatting position to a height of at least 24 inches*, return the load to the ground in a controlled manner, and descend the stairs. Stair-climbing may be unpowered. The winner is the competitor who lifts the most weight.

CHALLENGE 2:

Dexterity. Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.

CHALLENGE 3:

Walking Race. Walk the 100 foot* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.



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*Specifics of the competition are in a tentative state and may be subject to change.

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PowerSupply1 Switching Power Supplies



New to **CircuitSpecialists.com** are these Highly Reliable, Universal AC input/full range single output power supplies. Choose between various 40, 60, 100 & 150 Watt versions. They have the approval of UL and cUL and come 100% full load burn-in tested and are protected with overload/over and voltage/short circuit. Also included is a 2 year warranty.

PowerSupply1	Qty 1	Qty 10	Qty 25	Qty 100	Qty 500	Qty 1000
40W Series Available in 5,12,15,24,48V	\$28.99	\$26.09 ^{ea}	\$24.53 ^{ea}	\$21.95 ^{ea}	\$15.98 ^{ea}	\$13.79 ^{ea}
60W Series Available in 5,12,15,24,48V	\$32.99	\$29.69 ^{ea}	\$27.91 ^{ea}	\$25.95 ^{ea}	\$17.69 ^{ea}	\$15.49 ^{ea}
100W Series Available in 3,3,5,7.5,12,15,24,48V	\$38.50	\$34.65 ^{ea}	\$32.57 ^{ea}	\$29.99 ^{ea}	\$21.18 ^{ea}	\$18.49 ^{ea}
150W Series Available in 5,7.5,9,12,24,28,36V	\$48.99	\$44.09 ^{ea}	\$39.00 ^{ea}	\$37.50 ^{ea}	\$26.93 ^{ea}	\$23.49 ^{ea}

NEW!

Programmable DC Power Supplies

The CSI 3600 Series Programmable DC Power Supplies are equipped with a back-lit LCD display, number keypad and a rotary code switch for ease of use & quick programming. Voltage, Current & Power can all be displayed on the LCD or computer screen (with optional RS-232 interface module). It can be operated at constant current mode, constant voltage mode & constant power mode. It also can be set with maximum limits for current & power output. Ideal instruments for scientific research, educational labs or any application requiring a sophisticated DC-power source.



Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W

Only \$199.00 Each!

www.CircuitSpecialists.com

Circuit Specialists Soldering Station w/Ceramic Element & Separate Solder Stand

- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
- 3-prong grounded power cord/static safe tip
- Separate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

\$34.95!



Item# **CSI-STATION1A** *Rapid Heat Up!*

Also Available w/Digital Display & MicroProcessor Controller



Item# **CSI-STATION2A**
\$49.95

Details at Web Site

SMD Hot Tweezer
Adaptor Fits CSI Stations 1 & 2, and also CSI906

Item# **CSITWZ-STATION**



> Soldering Equipment & Supplies > Soldering Stations

In Business

Circuit Specialists Inc.

Since 1971



Programmable DC Electronic Loads

The CSI 3700 series electronic loads are single input programmable DC electronic loads that provide a convenient way to test batteries and DC power supplies. It offers constant current mode, constant resistance mode and constant power mode. The backlight LCD, numerical keypad and rotary knob make it much easier to use. Up to 10 steps of program can be stored.



Model	CSI3710A	CSI3711A
Input Voltage	0-360V DC	0-360V DC
Input Current	0-30A DC	0-30A DC
Input Power	0-150W	0-300W

CSI3710A: \$349.00 **CSI3711A: \$499.00**

Bullet Style B/W Camera

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" LG CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2



Item# **VC-305**

1-4:\$49.00 5+:\$46.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

13.8V DC Regulated Linear Power Supplies

Rugged power supplies that provide 13.8 Volts and substantial amounts of current! Suitable for various applications including Automotive, Marine and Radio Equipment, along with High-Amp Stepper Motors and CNC (Computer Numeric Control) Machines. Choose from three models; **CSI1862** with 6 Amps, **CSI-1865** with a robust 20 Amps or **CSI-1869** with a beefy 40 Amps at your disposal.

Item#	Current	Price
CSI1862: (6A)		\$24.95
CSI-1865: (20A)		\$69.00
CSI-1869: (40A)		\$119.00



Details at Web Site > Test Equipment > Power Supplies > DC Power Supplies

Dual Output DC Bench Power Supplies

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

- Source Effect: $5 \times 10^{-4} = 2mV$
- Load Effect: $5 \times 10^{-4} = 2mV$
- Ripple Coefficient: <250uV

As Low As \$93.00!

HOT ITEM!



*Both Models have a **1A/5VDC Fixed Output** on the rear panel*

CSI3003X-5: 0-30v/0-3amp/1-4..\$97.00/5+..\$93.00

CSI5003X-5: 0-50v/0-3amp/1-4..\$107.00/5+..\$103.00

Details at Web Site > Test Equipment > Power Supplies

Triple Output Bench Power Supply with Large LCD Displays



CSI3003X3/\$179.00
(qty 5+/\$169.00)

Output: 0-30VDC x 2 @ 3 AMPS & 1ea. fixed output @ 5VDC@3A
Source Effect: $5 \times 10^{-4} = 2mV$
Load Effect: $5 \times 10^{-4} = 2mV$
Ripple Coefficient: <250uV
Stepped Current: 30mA +/- 1mA
Input Voltage: 110VAC

Details at Web Site

> Test Equipment > Power Supplies

High Capacity Nickel Metal Hydride Rechargeable Batteries



Item#		1+	10+	100+
AA2500	"AA" cell 2500mAh	\$1.45	1.25	1.09
AAA850MAH	"AAA" cell 850mAh	\$0.99	0.65	0.51
C3500MAH	"C" cell 3500mAh	\$2.99	2.30	2.09
D11000MAH	"D" cell 11000mAh	\$6.95	5.55	4.39
9V220MAH	"9V" cell 220mAh	\$3.69	3.29	2.99

Details at Web Site

> Batteries & Accessories > NiMH Batteries

Premier Repairing System w/Power Supply

Microprocessor controlled design that provides stability and precision of temperature and airflow settings during the rework process. A full digital display of temperature and power source make everything clear to the user while the unit provides vast flexibility at the rework station with the built-in adjustable power supply that provides 0-15V and 2A of power. Hot air soldering and adjustment of temperature are controlled by a micro chip and sensor thus giving tremendous accuracy and reliability.

Item# **CSI768****Only \$289.00!**

- Iron Output Voltage: 24V / 35W
- Temperature Range: 100-480°C / 212-896°F
- DC Power Supply: 0-15V / 2A

[Details at Web Site](#) > [Soldering Equipment & Supplies](#)
2.9GHz RF Field Strength Analyzer

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz. The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions.

Item# **3290**
[Details at Web Site](#) > [Test Equipment](#) > [RF Test Equipment](#)
Fantastic Low Price: \$1899.00!

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simultaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All functions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker **(Includes Antenna)**

B&W Pinhole Bullet Camera w/ 1/3" CCD

- Weather Resistant Housing
- Signal System: EIA
- Image Sensor: 1/3" CCD Bullet Hole
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

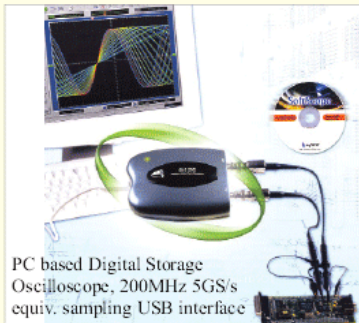
Item# **VC-305CP**

1-4:\$49.00

5+:\$46.00

[Details at Web Site](#)
> [Miniature Cameras \(Board, Bullet, Mini's, B/W, Color\)](#)**4 Channel Digital Video Recorder w/200GB HD Installed**

- Signal System: NTSC
- Operation System: Embedded RTOS
- Video Input: BNC x 4
- Video Output: BNC x 1 / VCR OUT
- Resolution: NTSC 720x480/ NTSC 640x240
- Record Frame Rate: 30fps total
- HD Capacity: 200GB
- Backup: VCR
- Alarm In/Out: 4 in NO/NC, 1 Out No

Item# **VR-214-200G****Only \$389.00**
[Details at Web Site](#) > [Miniature Cameras \(Board, Bullet, Mini's, B/W, Color\) & Security](#)
Digital Storage Oscilloscope Module

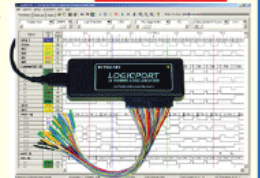
PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

[Details & Software Download at Web Site](#)
SALE!> [Test Equipment](#) > [Oscilloscopes/Outstanding Prices](#)Item# **200DSO** Only **\$829.00****LogicPort Logic Analyzer**

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

[Details at Web Site](#) > [Test Equipment](#) > [Logic Analyzers](#)
Item# **LOGICPORT****\$369.00!****Plug-In Switching Power Supplies**

These 15W switching power supplies are an inexpensive way to power devices with robust regulated power and low ripple noise. The low-profile design allow you insert them into a power strip without losing any of the other plugs. Designed with an energy efficient switching technology, the **Universal AC input works from 90-264VAC** with no minimum load required and a 100% burn-in test to ensure they will perform as stated right out of the box. They come with a 1.8 meter output cord and a 5.5 x 2.1mm female plug. UL and cUL approved.



Item#	Description
3A-161WU05	5 Volts / 2.6 Amps
3A-161WU06	6 Volts / 2.5 Amps
3A-161WU09	9 Volts / 1.70 Amps
3A-161WU12	12 Volts / 1.25 Amps
3A-161WU18	18 Volts / 0.84 Amps
3A-161WU24	24 Volts / 0.63 Amps

Each	10+	25+	100+
\$9.95	\$8.95	\$8.49	\$6.95

[Details at Web Site](#) > [Test Equipment](#) > [Power Supplies](#)
SONY Super HAD CCD Color Weatherproof IR Cameras

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# **VC-827D** 1-4:\$149.00 5+:\$139.00**SONY Super HAD CCD B/W Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-317D** 1-4:\$69.00 5+:\$65.00**SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity****SONY Super HAD CCD Color Camera**

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-805** 1-4:\$69.00 5+:\$65.00
[Details at Web Site](#)
> [Miniature Cameras \(Board, Bullet, Mini's, B/W, Color\)](#)**SONY Super HAD CCD Color Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-819D**

1-4:\$89.00 5+:\$79.00

**SONY Super HAD CCD Mini B/W Board Camera**

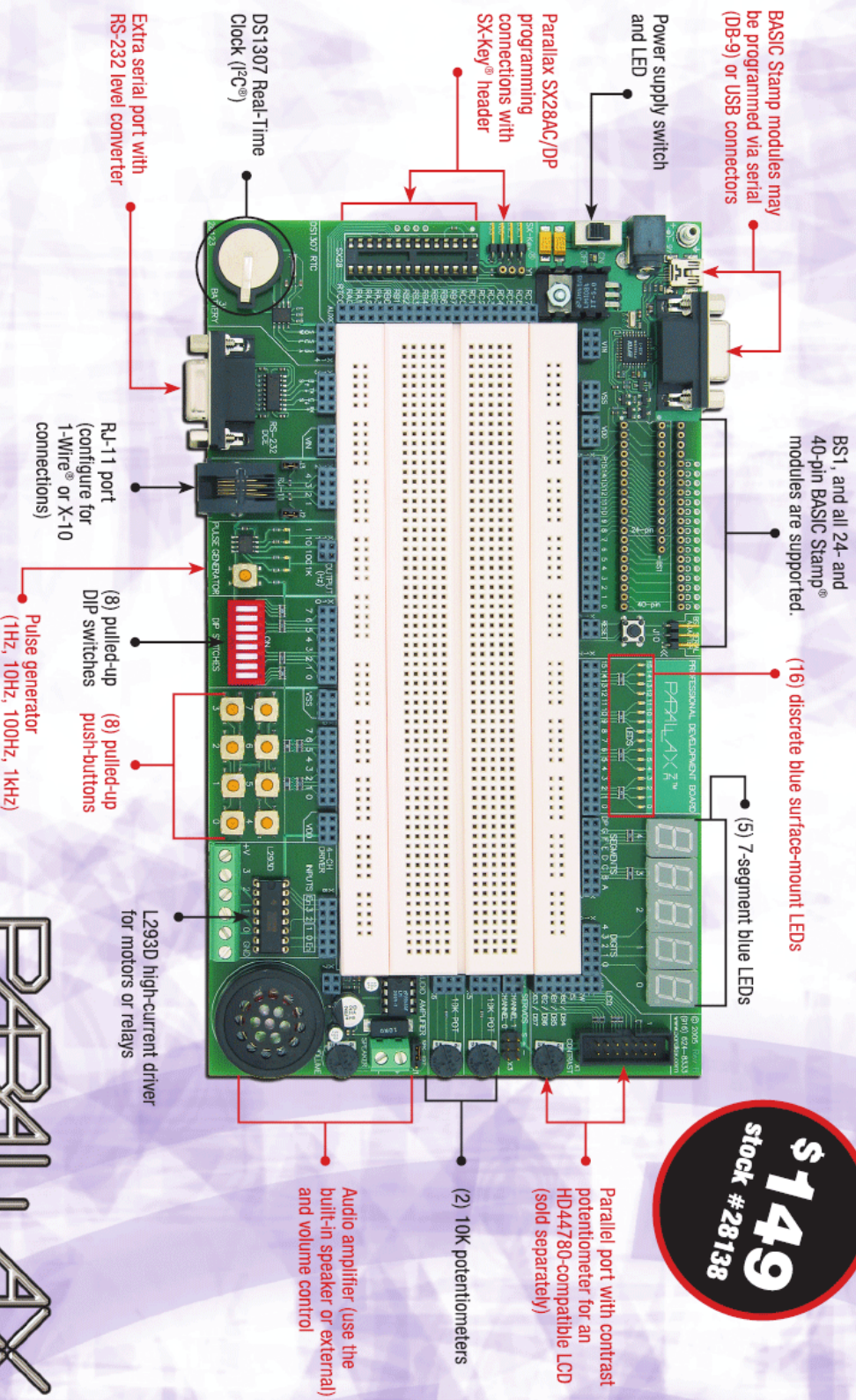
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV Lines
- Min. Illumination: .05Lux/F1.2

Item# **VC-103** 1-4:\$33.00 5+:\$29.00

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